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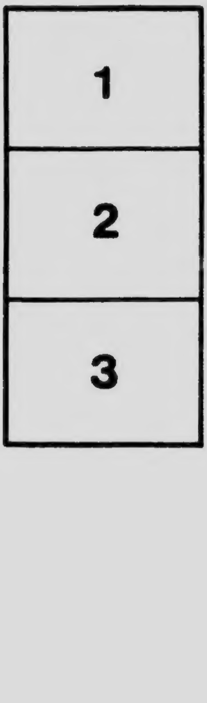

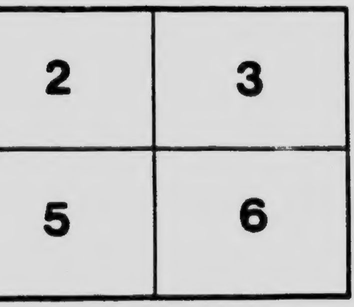

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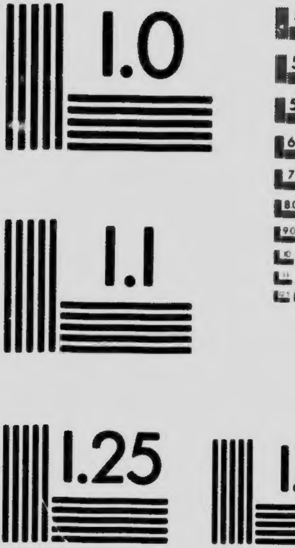

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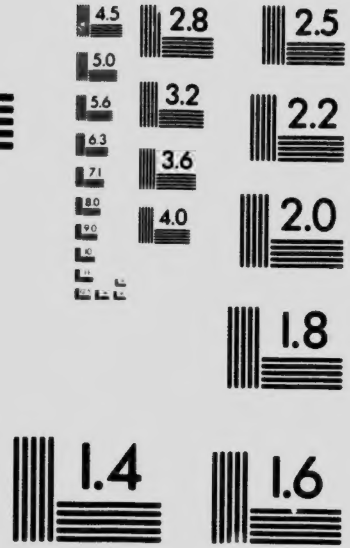

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YEARLY CALENDAR, 1911

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THE WESTINGHOUSE INDUSTRIES.

Westinghouse Electric & Mfg. Co., Pittsburg.
The Westinghouse Air Brake Co., Wilmerding.
American Brake Co., St. Louis, Mo.
The Westinghouse Machine Co., East Pittsburg, Pa., and Attica, N. Y.
The Union Switch & Signal Co., Swissvale, Pa.
Westinghouse Lamp Co., Bloomfield, N. J.
The Bryant Electric Co., Bridgeport, Conn.
The Perkins Electric Switch Mfg. Co., Bridgeport, Conn.
Pittsburg Meter Co., East Pittsburg, Pa.
R. D. Nuttall Co., Pittsburg, Pa.
Westinghouse Automatic Air & Steam Coupler Co., St. Louis, Mo.
Nernst Lamp Co., Pittsburg, Pa.
Westinghouse Trac. Br. Co., Wilmerding, Pa.
Cooper Hewitt Electric Co., New York, N. Y.
The Westinghouse Foundries Co., Trafford, Pa.
The Westinghouse Air Brake Co., Ltd., London, England, and Hanover, Germany.
The British Westinghouse Electric & Mfg. Co., Ltd., Manchester, England.
Societe Anonyme Westinghouse, Le Havre.
Westinghouse Electricitats - Actiengesellschaft, Berlin, Germany
Canadian Westinghouse Co., Ltd., Hamilton.
Campagnie Internationale Pour le Chauffages Des Cheminz De Fer Systeme Heintz, Ltd., London, England.
Campagnie Italiana Westinghouse dei Freni, Turin, Italy.
Societe Electrique Westinghouse De Russie, 11 Nevsky Prospect, St. Petersburg, Russia.
The Westinghouse Cooper Hewitt Co., Ltd., 2 Norfolk Street, Strand, W. C., London.
Societe Anonyme Westinghouse, St. Petersburg, 2 Prilloukskaia, St. Petersburg, Russia.
Westinghouse Electric Co., Ltd., London, Eng.
The Westinghouse Metal Filament Lamp Co., Ltd., London, England.
Holland-American Construction Co., London.
Societa Italiana Westinghouse, Genoa, Italy.
The Traction & Power Securities Co., Ltd., London, England.
Westinghouse Metallfaden Kluehlampenfabrik Gesellschaft, m. b. H., Vienna, Austria.

PITTSBURG AND THE WESTINGHOUSE INTERESTS.

Pittsburg lies where the Allegheny and Monongahela rivers join to form the Ohio. The Steel City is embraced in the greatest industrial region of the world. The daily wage roll is reputed to be over a million dollars. Steel and machinery are manufactured in immense quantities. The wealth that has accrued as a result of the city's industries expresses itself in scores of handsome office buildings, miles of beautiful homes, and extensive parks and boulevards.

The Westinghouse interests started humbly in Pittsburg and have been closely identified with the city's development. The growth of business required the removal of the works to less restricted quarters in a number of small towns adjoining Pittsburg on the east, and on the main line of the Pennsylvania Railroad, as shown in the accompanying map.

In Pittsburg, in the Westinghouse Building, corner Ninth & Penn, are the district offices of the Westinghouse Machine Co. and the Westinghouse Air Brake Co. The district office of the Westinghouse Electric & Manufacturing Co. is in the Union Bank Building, Fourth and Wood Sts. The office of the Cooper Hewitt Electric Co. is in the Wabash Building. At Garrison Place and Fayette Street are located the works of the Nernst Lamp Co. and of the R. D. Nuttall Co., manufacturers of gears, pinions and trolleys.

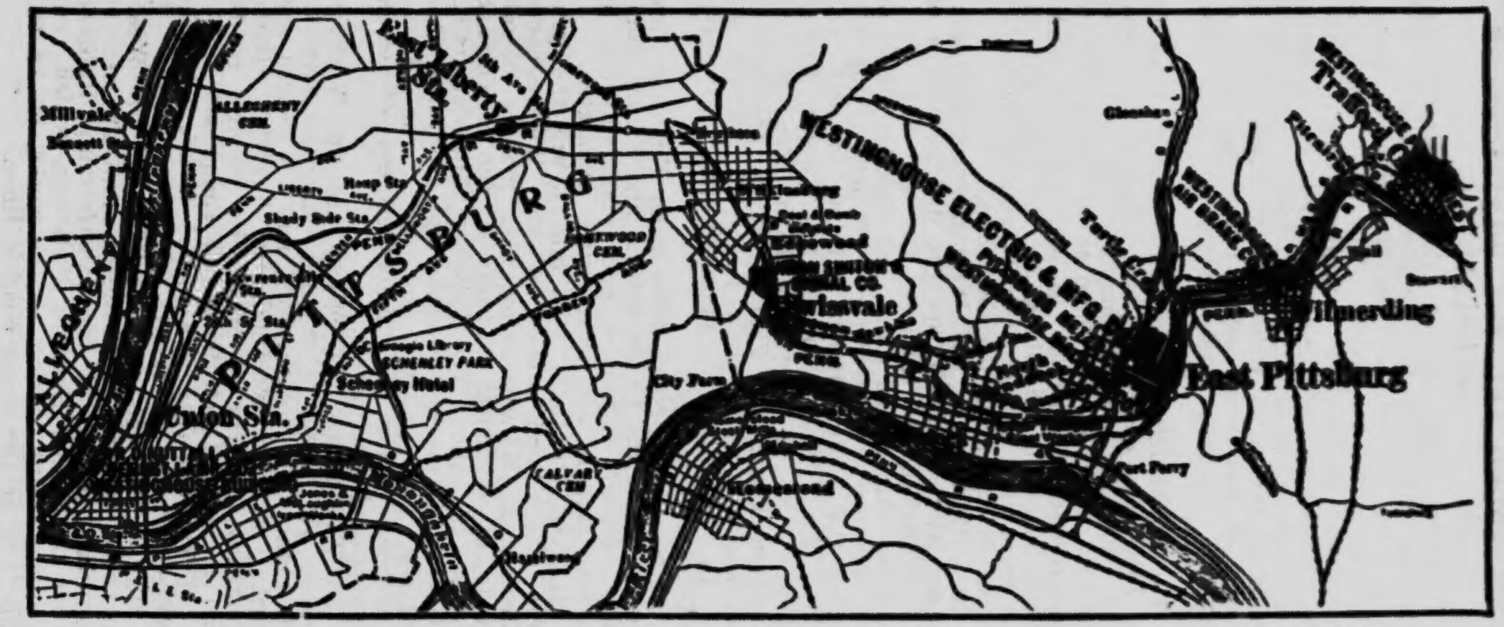
At Swissvale, eight miles from Pittsburg, are the works of the Union Switch and Signal Company, signal engineers and manufacturers of railway signals and interlocking apparatus.

At East Pittsburg (12 miles) are the general offices and works of the Westinghouse Electric & Manufacturing Co., makers of all kinds of electrical apparatus; the office and works of the Westinghouse Machine Co., makers of steam engines and turbines, gas engines, and stokers; and the works of the Pittsburg Meter Co., manufacturers of water meters and gas meters.

At Wilmerding (14 miles) are the Westinghouse Air Brake Company, manufacturers of air brakes and compressors, and the offices and works of the Westinghouse Traction Brake Company, makers of brakes for electric roads, and motor and belt-driven air compressors.

At Trafford City (18 miles) is the Westinghouse Foundry Company.

The visitor can most easily reach the Westinghouse plants by availing himself of the suburban service of the Pennsylvania Railroad from the Union Station, Pittsburg, which runs frequent trains passing all the works, or he can take one of the many electric lines.



MAP SHOWING LOCATION OF WESTINGHOUSE INDUSTRIES IN VICINITY OF PITTSBURG.

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THE SINGLE-PHASE RAILWAY SYSTEM.

The essential advantages of the alternating current single-phase system are the higher trolley voltage possible, reduction in transmission and transformer costs and the elimination of rotary-converter sub-stations. It is to these that the saving both in first cost and in expense of operation is due. A minor advantage is efficient and flexible speed control, every point being a running point without loss from resistance.

Car equipments can be furnished with either hand or multiple-unit control for the same capacities as direct current. Where necessary, cars may be supplied which will operate on either direct or alternating current to permit running over sections of direct-current line.

Equipments can be supplied to cover ordinary requirements for interurban service or for large freight or passenger locomotives.

The voltages adopted as standard for single-phase railway work are 6600 and 11000. Standard catenary line material can be supplied for either voltage.

For supplying power to single-phase roads, three-phase generators are generally employed, two leads only being used, the third lead being allowed to remain idle.

Westinghouse-Baldwin Electric Locomotives for Heavy Railroad Service.

In May, 1905, the Westinghouse Electric & Mfg. Company completed the first heavy locomotive (136 tons) to be operated by single-phase alternating current. This machine was built for the purpose of demonstrating the possibilities and advantages of single-phase current for heavy electric traction and to demonstrate the ability of the company to supply such apparatus.

Since this locomotive was built and tested, many single-phase locomotives have been built and are now operating in all classes of service with signal success.

The following are typical as showing the variety of service to which these locomotives have been applied.

New York, New Haven & Hartford R. R.

Thirty-five single-phase passenger locomotives were originally supplied. These locomotives are of the double-truck type, equipped with four gearless, commutator-type, single-phase motors, each motor having a nominal rating of 250 H.P. After six months' operation, six additional locomotives, duplicates of the first, making 41 in all, were supplied. In the last year, two additional freight locomotives of 1500 H.P. each (one with 4 geared motors and one with 2 side connected motors) have been equipped and delivered. In addition to the locomotive equipment, four motor cars and six trailers have been furnished for suburban service.

These locomotives operate over 12 miles of track electrified by means of third-rail 600-volt direct current, and over 22 miles of track equipped with double-catenary trolley line construction furnishing 11,000-volt, 25-cycle, single-phase current. The locomotives are used in both local and express service, frequently hauling trains of 300 to 450 tons weight. In express service, speeds of over 80 miles per hour have been attained.

The new freight locomotives were required by contract to handle a 1500 train at 35 miles per hour or an 800 ton passenger train at 45 miles per hour. In actual test, a freight train of 2100 tons was started and accelerated on an up grade of .3% around a curve and the passenger train was easily handled.

Service was begun on this line as far as New Rochelle during July, 1907; and was later extended to Stamford, the full distance, in October, 1907. All trains running into New York on this line have been pulled by single-phase electric locomotives since July 1, 1908.

Spokane & Inland Railroad.

Six electric freight locomotives were originally supplied, each weighing approximately 49 tons, and each equipped with four commutator-type, geared, single-phase motors, the nominal rating of each motor being 150 H.P. Later, three larger locomotives, weighing 72 tons each and equipped with four 175 H.P. motors, were furnished. Each locomotive unit can be operated separately or all may be coupled together and controlled as a single machine.

These locomotives will operate on either 600-volt direct-current or on 6600-volt, 25-cycle, single-phase current. Draw-bar pulls of 24,500 and 12,500 pounds can be maintained continuously at speeds of 10.5 and 15.5 miles per hour, respectively, and for short periods, on level track, a maximum pull of 45,000 pounds is available.

A pneumatically operated pantagraph is supplied for operation on the A.C. section and wheel trolleys for the D.C. The total length of track is 146 miles.

In 1910 two additional locomotives of the 72 ton type were added to this equipment.

Grand Trunk Ry., St. Clair Tunnel.

Six electric locomotives, each weighing 63 tons and equipped with three single-phase

SOME OF THE PRINCIPAL ELECTRIC LOCOMOTIVES SUPPLIED BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY FOR TRUNK LINE SERVICE.

Name of Road.	No. of Locos.	Type.	Weight.		No. of Driving Wheels.	Full Load Draw Bar Pull and Speed.	Max. Tractive Effort. Pounds.
			Total.	On Drivers.			
N. Y., N. H. & H. R. R..	41	Single-phase, Swivel Truck, 62" drivers.............	204,000	154,000	8	8,800 lbs. 55 M.P.H.	25,000
N. Y., N. H. & H. R. R..	1	Single-phase, Coupled Trucks, 63" drivers.....	273,000	192,000	8	12,000 lbs. 35 M.P.H.	48,000
N. Y., N. H. & H. R. R..	1	Single-phase, Articulated Double Cab Type, 57" drivers.................	270,000	185,000	8	12,000 lbs. 35 M.P.H.	48,000
Grand Trunk Ry. (St. Clair Tunnel).........	6	Single-phase, Rigid Wheel Base, 62" drivers.......	132,000	132,000	6	20,900 lbs. 12 M.P.H.	45,000
Spokane & Inland Ry....	5	Single-phase, Swivel Truck, 50" drivers.............	144,000	144,000	8	24,500 lbs. 10.5 M.P.H.	36,000
Spokane & Inland Ry....	6	Single-phase, Swivel Truck, 38" drivers.............	99,000	99,000	8	12,500 lbs. 15.5 M.P.H.	25,000
Lackawanna & Wyoming Valley Ry............	2	Direct Current, Swivel Truck, 36" drivers.............	100,000	100,000	8	11,650 lbs. 18.5 M.P.H.	25,000
Visalia Electric Ry......	1	Single-phase, Swivel Truck, 36" drivers.............	94,000	94,000	8	10,600 17 M.P.H.	23,500
Penn. Tunnel & Terminal Co...............	24	Direct Current Interpole, Articulated Double Cab Type, 72" drivers.............	313,000	200,000	8	10,000 lbs. 60 M.P.H.	79,200

motors of 240 H.P. each, are used for hauling both freight and passenger trains of the Grand Trunk Railway through the St. Clair Tunnel and have been in successful operation since March, 1908.

The locomotives are of the rigid wheel-base type and are arranged for operation on 3300-volt, 25-cycle, single-phase current.

Each locomotive is capable of exerting a maximum draw-bar pull of 45,000 pounds, and a running draw-bar pull of 25,000 pounds at 10 miles per hour. Two units are used together in regular service to handle a 1000-ton train through the tunnel and up the two percent grade. The length of the line is four miles and the running speed through the tunnel is 20 to 30 miles per hour.

DIRECT-CURRENT LOCOMOTIVES.

Pennsylvania Tunnel & Terminal R. R. Co.

The Westinghouse Electric & Mfg. Company has equipped for this service 24 of the most powerful electric locomotives in the world. They are used in hauling through passenger trains over the heavy grades in the Hudson and East River tunnels into the Manhattan terminal.

Characteristic Features
Pennsylvania Electric Locomotives
Direct Current—600 Volts
Westinghouse Unit Switch Field Control
Articulated Double Cab Type
Weights and Dimensions

Weight of locomotive, complete	156½ tons
Weight on drivers	100 tons
Weight on each driving axle	25 tons
Weight on each bogie truck	28¼ tons
Total length over all, inside knuckles	64 ft., 11 in.
Rigid wheel base of each half	7 ft., 2 in.
Total wheel base of each half	23 ft., 1 in.
Total wheel base of locomotive	55 ft., 11 in.
Diameter of drivers	72 inches

General Capacity

Contract tractive effort	60,000 lbs.
Maximum contract horse-power	4,000
Normal speed with full train	60 mi. per hr.
Actual maximum draw bar pull (recorded on test)	79,200 lbs.

Maximum Contract Normal Service

550 ton train to be started and accelerated on 2 per cent tunnel grades

Motor Data

Two Direct-Current Interpole Motors

Cast Steel Frames

Directly Connected Through Jack-Shafts and Side-Rods.

Weight of each motor complete with cranks....................48,000 lbs.
Height of motor frame above cab floor..........................5 ft., 6⅛ in.
Height of center of shaft above cab floor.....................2 ft. 1⅛ in.

DIRECT-CURRENT RAILWAY APPARATUS.

Interpole Motors.

A complete line of interpole railway motors ranging in size from 40 to 225 horsepower has been built to suit all classes of railway service. Experience gained from the operation of these motors of different sizes, aggregating over 150,000 H.P., shows that trouble arising from faulty commutator collection of the current have been practically eliminated. The interpoles are small poles placed between the main poles and excited by coils connected in series with the armature and of such a strength that the magnetic effect of the armature on the coils under the brushes is neutralized, so that there is no sparking at the brushes at any operating load or voltage. Interpole motors will withstand enormous overloads without damaging the commutator or producing flashing. With no burning of brushes and copper the life of brushes and commutator is more than trebled. Brushes show a life of from 100,000 to 150,000 miles.

DATA REQUIRED FOR SELECTION OF CAR EQUIPMENT.

Too much importance cannot be attached to the necessity of careful attention to selection of proper equipments for the service to be rendered.

In order to secure the best results, the following information should be furnished the manufacturer.

DATA.

A profile and map or dimensioned sketch of the road should be furnished. If these are not available, a list of grades (amount, direction and length of each), taken in the order in which they occur, and a list of curves (length and radius of each), with their location, should be supplied, together with any local features which may produce slow-downs in addition to the stops specified.

City, Suburban and Interurban running should be separately considered on each line and the following details supplied:

City Running:

Distance. . . . . —Miles
Time for trip one way. . —Minutes
Number of stops. . . . —Per trip
Average time of stops. . —Seconds

Suburban Running:

Distance. . . . . —Miles
Time for trip one way. . —Minutes
Number of stops. . . . —Per trip
Average time of stops. . —Seconds

Interurban Running:

Distance. . . . . —Miles
Time for trip one way. . —Minutes
Number of stops. . . . —Per trip
Average time of stops. . —Seconds

Hours of service. . . . . . —Daily
Layover at end of line. . —Minutes
Trolley Pressure—Maximum —Volts
Trolley Pressure—Minimum —Volts
Trolley Pressure—Average. —Volts
Gauge of track. . . . . . —ft. — in.

Motor Cars:

Length over—all. . . . —ft. — in.
Trucks—single or double
Wheel diameter. . . . —in. new, — in. old
Wheel base. . . . . —ft. — in.
Weight car body. . . . —lbs.
Weight trucks—1 or 2. —lbs.
Car will seat. . . . . . —Passengers

Trail Cars:

Length over—all. . . . —ft. — in.
Trucks—single or double
Weight of car body. . . .—lbs.
Weight of trucks—1 or 2.—lbs.
Car will seat. . . . . . —Passengers

The number of trailers, if any, to be handled by one motor car, time of trailer operation and whether any increase in running time will be allowed when handling trailers, should be stated.

Complete information regarding type of control is desirable.

For new equipments for existing roads, data should be furnished as to present car weights, motor type numbers, gear ratios, wheel diameters, schedules, stops, temperature of motor windings and commutators after all day operation and degree of satisfaction obtained with present equipments.

WESTINGHOUSE RAILWAY MOTOR RATINGS.

The nominal rating of Westinghouse motors is the load which may be carried during a run of one hour on the stand at the rated voltage and current without giving a greater rise in temperature than 75 degrees Centigrade, when measured by thermometer on the windings of the motor after the run, in accordance with the standards of the A. I. E. E.

In this connection it is important to remember that the conditions of external ventilation which exist under a moving car cause the temperature rise for given losses in the motor to be very much less than the rise for the same losses in a shop test on the stand.

Westinghouse railway motors are also given a current test for capacity in continuous service.

Experience has proven that the average of the voltages at the motor in all day city service does not exceed an equivalent impressed voltage of 300 and that the average of interurban operation does not exceed an equivalent impressed voltage of 400 volts. As the losses in a motor vary as the square of the current, the square root of the average of the squares of the currennt inputs of a motor during all day service will give an equivalent current which will produce the same heating effect.

All Westinghouse motors are tested with such an equivalent current and the capacity thereby established can be maintained in all day actual service without occasioning a greater temperature rise in the windings than 65 degrees C.

ROTARY CONVERTERS.

Westinghouse Standard Rotary Converters are built for use on both 25-cycle and 60-cycle circuits and for direct current voltages of 250 volts and 600 volts. Rotary converters of 25 cycles are in service in capacities as high as 3000 kw. and 60-cycle rotaries are in successful operation up to and including 1000 kw.

In general, standard rotary converters are designed for self starting from the A.C. end, and all may be started from the D.C. end where direct current is available for starting.

Rotary converters are a very efficient transforming device, and for this reason are economical for use on systems where the service required is suitable for rotary operation.

The combined efficiency at all loads of a rotary converter and transformers will, in general, be several percent higher than the efficiency of a generator set of equal capacity, transforming from the same A.C. voltage.

Rotary converters are suitable for use on a system where close D.C. regulation is required from a system having reasonably close A.C. regulation, or if close D.C. regulation is not required, rotaries will operate satisfactorily even though the regulation of the supply system varies materially

Westinghouse rotary converters are manufactured with synchronous regulators integral with the unit or with induction regulators separate from the unit for use where a variation in the D.C. voltage is required as for lighting systems.

Due to the fact that rotaries operate best at unity power factor, they are not desirable for power factor correction requiring heavy leading currents in the rotary.

Where conditions warrant using rotaries, the high efficiency and lower first cost, together with the fact that they are protected from line disturbances by transformers, makes them generally preferable to motor generators.

MOTOR GENERATORS.

Westinghouse standard motor generators are built for both 25-cycle and 60-cycle circuits in sizes up to and including 2000 kw., utilizing either synchronous or induction motors. Standard synchronous motor generators are arranged for self starting from the A.C. end, and all sets may be started from the D.C. end.

In general, motor generators may be used without step down transformers on A.C. voltages up to and including 6600 volts. D.C. voltages for standard motor generators are 250 volts and 600 volts.

Motor generators are applicable: Where a D.C. regulation is required entirely independent of the regulation of the supply system; where corrective effect is required to overcome low power factor, by using motor generator operating partially as a synchronous condenser; where it is desired to operate the set either regularly or inverted; on the end of a long transmission line where the ohmic drop is great; and where the regulation of the supply system is so ragged as to preclude the use of synchronous apparatus, in which case an induction motor generator is preferable.

WESTINGHOUSE TRANSFORMERS.

Westinghouse transformers are manufactured in the following five main classes:

1. Air-Blast (AB).
2. Oil-Insulated Water-Cooled (OIWC).
3. Oil-Insulated Oil-Cooling (OISC).
4. Distributing ("S"-"SA"-"SK").
5. Detail Transforming Apparatus, consisting of Constant-Current Regulators, Mercury-Arc Rectifiers, Instrument Transformers, Tungsten Economy Coils, Bell Ringers, etc.

Air-Blast Transformers employ the "shell" form of construction, and are built for any capacity from 100 KVA up, for any frequency, and for any voltage up to 33,000. Air-Blast Transformers for voltages above 33,000 are impracticable on account of the space required for insulation. However, where star-connected with the neutral carefully grounded, air-blast transformers may be used on circuits up to 50,000 volts. About 150 cubic feet of air per minute is required for each KW of loss in the transformer at pressures from one-half to one ounce per square inch.

OIWC Transformers are built for any capacity from 100 KVA up, and for any frequency and voltage. They are of the "shell" or "core" types, depending on the capacity and voltage. They are mounted in welded boiler-iron cases with cast-iron covers fitted with manholes. The cooling coils of seamless brass tubing are subjected to 250 pounds pressure test. Approximately one-fourth gallon of water per minute is required for each KW loss in the transformer.

OISC Transformers are of the shell or core type as determined by the capacity and voltage. They are, for sizes up to approximately 750 KVA mounted in corrugated sheet iron cases having the top and bottom cast on. Cases are fitted with cast-iron covers. Above this size and up to 3000 KVA the cases are of the tubular type. They are made of boiler iron and have boiler tubes welded in to provide surface for radiation.

The standard lines of Westinghouse transformers are as follows:

Standard capacities: 100, 110, 125, 150, 185, 200, 250, 300, 400, 500, 600, 750, 1000, 1250, 1500, 2000, 2500, 3000, 3500 and 4000 KVA.

Standard voltage classes: 2200, 6600, 11,000, 16,500, 22,000, 33,000, 44,000, 55,000, 66,000, 77,000 88,000, 100,000 and 110,000 volts.

Standard frequencies are 25 and 60 cycles.

When ordering Westinghouse transformers, standard capacities, voltages and frequencies should be specified wherever possible, as this will greatly facilitate delivery. Give all the information possible, such as KVA capacity, type, phase, cycles, high tension and low tension voltages, service conditions and data as to taps and parallel operation with other transformers.

All the above types of transformers are built in either single or three-phase types. The advantages of a three-phase transformer over three single-phase transformers having an equivalent combined capacity are: Smaller floor space, lighter weight, higher efficiency, simpler installation and lower cost. The disadvantages of the three-phase type are: Greater cost of spare units, greater cost of repairs, greater derangement of service in case of breakdown, and difficulty of bringing out taps for a large number of voltages.

It will be noted that the disadvantages of three-phase transformers relate almost entirely to failure of the apparatus. With the advance in the art of design, however, the chances of failure are greatly diminished, so that the disadvantages stated can be practically cancelled.

The notable reliability of modern transformers renders it good practice to employ three-phase transformers instead of equivalent groups of single-phase units, in all cases except small installations (where a spare unit would mean a large percent increase in station cost and where a failure would cause a great derangement of service).

All OIWC, OISC and Air-Blast transformers are so designed that the entire transformer can be lifted as a unit. It is the standard practice of the Westinghouse Company to ship OIWC and OISC transformers in their cases complete with oil, except where handling and transportation do not permit. This reduces the expense of installation and eliminates time required for drying out.

OIWC and OISC transformers of voltage classes exceeding 66,000. and for indoor installation, are fitted with condenser-type terminals. In this terminal the voltage stresses are distributed equally throughout the material and not concentrated at the surface as is the case with the ordinary type of terminal.

Distributing transformers of the "S" and "SA" class are of the "shell" type and are mounted in cast-iron cases. Standard sizes range from ½ to 50 KVA. The standard frequencies are 25 and 60 cycles, the standard voltage being 2200. The "SK" class covers distributing transformers of 4400 volts and above. The "core" type of construction is employed for this class.

Non-aging iron is used in all standard Westinghouse transformers.

Westinghouse Constant-Current Regulators are made in air-cooled and oil-cooled types. Standard air-cooled sizes are 6, 12, 25, 35, 50 and 75-light, standard oil-cooled sizes are 100, 150 and 200-light, for 2200 volts and 60 cycles.

Westinghouse Mercury Rectifier Apparatus is built in two principal lines:—Outfits for series street lighting using metallic arcs, and battery-charging outfits.

The superior characteristics of direct-current series arcs are rendered available without the complexity and inefficiency of the constant-current generator, by employing rectifier outfits. For lighting service these are mounted in boiler-iron tanks and are oil-immersed. Standard sizes are 25, 35, 50, 75 and 100 lights. Standard rectified currents are 4 and 6.6 amperes. Standard frequencies are 25 and 60 cycles. Though usually built for nominal 2,200-volts primary, the outfit may be designed for primary pressures up to 13,200 volts. without using step down transformers.

Westinghouse Standard Battery Charging Outfits are designed to supply from 2 to 44 cells of battery and are made in sizes up to 30 amperes direct-current output, according to rating. Standard outfits are for 60 cycles and 220 or 110-volt A.C. circuits, but special outfits are made.

Instrument Transformers—voltage and current—are built in a wide range of styles.

Some important installations of Westinghouse Air-Blast Transformers:

Operating Company.	Location.
Brooklyn Edison Co..........	Brooklyn, N. Y.
Chambly Mfg. Co.............	Montreal, Can.
Consol. Gas, Elec. Lt. & Pr. Co.	Baltimore, Md.
Capital Traction Co..........	Washington, D. C.
Interborough Rpd. Trnst. Co...	New York City.
Long Island R. R. Co........	New York City.
Louisville Ry. Co............	Louisville, Ky.
Louisville Lighting Co........	Louisville, Ky.
New York Edison Co..........	New York City.
New York & Queens Co. Ry...	New York City.
New York & Queens Elec. Lt. & Pr. Co.................	New York.
Penna. Tunnel & Terminal R. R. Co................	New York City.
New York, New Haven & Hartford R. R...............	
Philadelphia Rapid Transit Co.	Philadelphia, Pa.
Public Service Corp. of New Jersey...................	
Reading Pr. Co., Reading, Pa..	Reading, Pa.
Third Avenue R. R. Co......	New York City.
Transit Development Co......	Brooklyn, N. Y.
United Elec. Lt. & Pr. Co....	New York City.
United Ry. & Elec. Co........	Baltimore, Md.
Vancouver Power Co.........	Vancouver, Can.

A FEW OF THE HIGH-POTENTIAL TRANSMISSION PLANTS IN AMERICA USING WESTINGHOUSE TRANSFORMERS.

Name.	Location.	Voltage.	Freq.	K.V.A.	Miles
Grand Rapids-Muskegon Power Co.	Grand Rapids, Mich.	110,000	30	20,000	50
Southern Power Co.	Charlotte, N. C.	110,000	60	64,000	220
Hydro-Electric Power Commission of Ontario.	Toronto, Canada.	110,000	25	30,000	250
American River Electric Co.	San Francisco, Cal.	110,000	60	4,500	110
Rio de Janiero Tramways, Light & Power Co.	Rio de Janiero, Brazil.	88,000	60	80,000	60
Telluride Power Co.	Provo, Utah.	80,000	60	30,000	110
United Missouri River Power Co.	Helena, Mont.	70,000	60	40,000	100
Central Georgia Power Co.	Macon, Ga.	66,000	60	12,000	75
Idaho-Oregon Light & Power Co.	Boise City, Idaho.	66,000	60	16,000	80
Spokane & Inland Empire Railway Co.	Spokane, Wash.	66,000	25 & 60	44,000	100
Ontario Power Co.	Niagara Falls, Ont.	60,000	25	80,000	200
Pennsylvania Water & Power Co.	Baltimore, Md.	60,000	25	40,000	100
Northern California Power Co.	Redding, Cal.	60,000	60	10,000	60
West Kootenay Power Co.	Rossland, B. C.	60,000	60	35,000	60
Rochester Railway & Light Co.	Rochester, N. Y.	57,000	25	8,000	30
Nevada-California Power Co.	San Francisco, Cal.	52,000	60	10,000	50
Seattle-Tacoma Power Co.	Seattle, Wash.	50,000	60	50,000	100
Taylor's Falls Power Co.	Taylor's Falls, Minn.	50,000	88	10,000	40
Shawinigan Water & Power Co.	Montreal, Canada.	50,000	30	15,000	80
Indiana & Michigan Electric Co.	Berrien Springs, Mich.	47,800	60	15,000	50
Dominion Power & Transmission Co.	Hamilton, Ont.	45,000	60	25,000	40
Southern Power Co.	Charlotte, N. C.	44,000	60	100,000	150

POWER FACTOR.

The power factor of an alternating-current circuit is the number by which the apparent power in the circuit, (volts times amperes), must be multiplied in order to ascertain the true power. When an alternating-current circuit contains inductance, the current lags behind the e.m.f., and when it contains capacity the current rises ahead of the e.m.f.; in each case the current and e.m.f. reach their maximum values at different instants, and the product of the e.m.f. and current at any instant is less than it would be if the two were in phase with each other. If the e.m.f. and current be measured separately, the voltmeter and ammeter will give the individual mean effective values; if they are measured by a wattmeter, the instrument indicates their combined effect synchronously, not the product of their effective values which occur at different instants; consequently, the wattmeter indication will be less than the product of the separate voltmeter and ammeter readings. The ratio of the power to this product is the power factor of the circuit. Expressed as a formula:

$$\text{Power Factor} = \frac{\text{Watts.}}{\text{Amperes x Volts.}}$$

This gives rise to the two methods of rating electrical apparatus, one on the basis of watts or kilowatts, and the other on the basis of volt-amperes or kilovolt-amperes (Kva.).

The former represents the actual power, usually in Kw., the latter the apparent power, usually in Kva., generated, transmitted or used by the apparatus. The latter, or Kva., rating is coming into more general use since it represents more adequately the voltage and current conditions to which the apparatus is subjected.

WEIGHT OF COPPER.

A convenient formula for weight of copper in a line is as follows:

$$\text{Lbs. copper in line} = \frac{(\text{miles})^2 \text{ x kilowatts}}{(\text{kilovolts})^2 \text{ x \% loss x k.}}$$

k = a constant depending on phase, system, and power factor; for 100% power factor, single or two-phase, k = 868; for three-phase k = 278.

TABLE OF DIMENSIONS, WEIGHTS AND RESISTANCES OF PURE COPPER WIRE (BARE).

Brown & Sharpe Gauge.

Gauge No.	Diam. Inches	AREA		WEIGHT	LENGTH
		Circular mils (d^2). 1mil. =.001 inch.	Sq. Mils. (d^2x. 7854)	Lbs. per 1000 ft.	Feet per lb.
....	1.152	1000000.	785400.	3050.	.3275
....	1.035	800000.	628000.	2440.	.4100
....	.963	700000.	549500.	2135.	.4680
....	.891	600000.	471000.	1830.	.5460
....	.819	500000.	392000.	1525.	.6550
....	.728	400000.	313900.	1220.0	.8200
....	.590	250000.	196000.	762.0	1.32
0000	.4600	211600.	166190.	639.3	1 56
000	.4096	167805.	131790.	507.0	1.97
00	.3648	133079.	104520.	402.0	2.49
0	.3248	105538.	82887.	318.8	3.14
1	.2893	83694.	65733.	252.8	3.99
2	.2576	66373.	52130.	200.5	4.99
3	.2294	52634.	41339.	159.0	6.29
4	.2043	41742.	32784.	126.1	7.93
5	.1819	33102.	25998.	100.0	10.00
6	.1620	26250.	20617.	79.32	12.61
7	.1442	20816.	16349.	62.90	15.90
8	.1284	16509.	12960.	49.88	20.05
9	.1144	13094.	10284.	39.56	25.28
10	.1018	10381.	8153.	31.37	31.38
11	.0907	8234.	6467.	24.88	40.20
12	.0808	6529.	5128.	19.73	50.69
13	.0719	5178.	4067.	15.65	63.91
14	.0640	4106.	3225.	12.44	80.38
15	.0570	3256.	2557.	9.84	101.63
16	.0508	2582.	2028.	7.81	128.14
17	.0452	2048.	1608.	6.19	161.59
18	.0403	1624.	1275.	4.91	203.76
19	.0358	1287.	1011.	3.88	257.47
20	.0319	1021.	802.2	3.09	324.00
21	.0284	810.1	636.2	2.45	408.56
22	.0253	642.7	504.7	1.94	515.15
23	.0225	509.4	400.1	1.51	649.66
24	.0201	404.0	317.3	1.22	819.21
25	.0179	320.4	251.6	.97	1032.9
26	.0159	254.0	199.5	.77	1302.6
30	.0100	100.5	78.9	.30	3293.9
36	.0050	25.0	19.6	.08	13238.
40	.0031	9.9	7.7	.03	33175.

For sizes above No. 0000 the table refers to stranded copper cable. Due to the conditions imposed by proper "laying" of the strands, the figures for circular mileage, diameter, resistance, etc., can be given with only approximate accuracy.

TABLE OF DIMENSIONS, WEIGHTS AND RESISTANCES OF PURE COPPER WIRE (BARE).

Brown & Sharpe Gauge.

RESISTANCE AT 75.° F.			Carrying Capacities		
Length. Feet per Ohm.	R Ohms per 1,000 ft.	Ohms per lb.	Rubber Ins. Amps	Other Ins. Amps	Gauge No.
95100.	.01051	.000003442	650	1000	....
76100.	.01313	.000005380	550	840	....
66600.	.01501	.000007030	500	760	....
57100.	.01751	.000009579	450	680	....
47500.	.02101	.00001376	390	590	....
38050.	.02627	.00002155	330	500	....
23750.	.04203	.00005600	275	412	....
20383.	.04906	.00007673	210	312	0000
16165.	.06186	.00012039	177	262	000
12820.	.07801	.00019423	150	220	00
10166.	.09838	.00038500	127	185	0
8062.3	.12404	.00048994	107	156	1
6393.7	.15640	.00078045	90	131	2
5070.2	.19723	.0012406	76	110	3
4021.0	.24869	.0019721	65	92	4
3188.7	.31361	.0031361	54	77	5
2528.7	.39546	.0049868	46	65	6
2005.2	.49871	.0079294	38	54	7
1590.3	.62881	.012608	33	46	8
1261.3	.79281	.020042	28	38	9
1000.0	1.	.031380	24	33	10
793.18	1.2607	.050682	20	27	11
629.02	1.5898	.080585	17	23	12
498.83	2.0047	.12841	14	20	13
395.60	2.5278	.20322	12	16	14
321.02	3.1150	.31658	....	....	15
248.81	4.0191	.51501	6	8	16
197.30	5.0683	.81900	....	....	17
156.47	6.3911	1.3023	8	5	18
123.99	8.0654	2.0759	....	....	19
98.40	10.163	3.2926	....	....	20
78.06	12.815	5.2355	In lighting work, no smaller than No. 14 is used, except for fixtures.		21
61.91	16.152	8.3208			22
49.08	20.377	13.238			23
38.91	25.695	21.050			24
30.86	32.400	33.466			25
24.46	40.868	55.235			26
9.681	103.30	340.25			30
2.408	415.24	5497.4			36
.932	1049.7	34823.			40

One foot of pure copper wire of one circular mil cross-sectional area (diameter, .001 inch), has a resistance of 10.74 ohms at 15°C or 59°F.

HOW TO REMEMBER THE WIRE TABLE.

A wire which is three sizes larger than another wire has half the resistance, twice the weight and twice the area. A wire which is ten sizes larger than another wire has one-tenth the resistance, ten times the weight and ten times the area.

No. 10 wire is 0.10 inch in diameter (more precisely 0.102); it has an area of 10,000 circular mils (more precisely 10,380); it has a resistance of 1 ohm per thousand ft. at 20 degrees Centigrade (68 degrees Fahrenheit), and weighs 32 pounds (more precisely 31.4 pounds) per thousand feet.

The weight of one thousand feet of No. 5 wire is 100 pounds.

The relative values of resistance (for decreasing sizes) and of weight and area (for increasing sizes) for "consecutive" sizes are: .50, .63, .80, 1.00, 1.25, 1.60, 2.00.

To find resistance, drop one cypher from the number of circular mils; the result is the number of feet per ohm.

To find weight, drop four cyphers from the number of circular mils and multiply by the weight of No. 10 wire.

SPECIFIC RESISTANCE OF METAL WIRES.

Material	Resistance Ohms per Milfoot, 0°C	Relative Resistance to Copper	Percentage Increase Degree C
Silver (annealed).	8.78	.97	.377
Silver (hard drawn) ...	9.54	.99	.377
Copper	9.53	1.00	.388
Gold	12.78	1.34	.365
Aluminum ..	17.48	1.83	.390
Zinc	33.76	3.54	.365
Platinum ...	54.35	5.70	.247
Iron	58.31	6.12	.453
Nickel	74.78	7.85	....
Tin	79.29	8.33	.365
Lead	115.10	12.09	.387
German Silver	125.7	13.18	.044
Antimony ..	213.7	22.35	.389
Mercury	565.9	59.40	.072
Bismuth	787.5	82.60	.354

COMPARISON OF COPPER AND ALUMINUM.

	Copper.	Al'um.
Specific gravity, ...	8.93	2.68
Conductivity for equal area, .	100.	63.
Weight for equal conductivity,	100.	48.
Area for equal conductivity, .	100.	160.
Diameter for equal conductivity,	100.	126.

It will be noted from the relative diameters that an aluminum wire to be of equal conductivity with a copper wire is almost exactly two sizes larger by B. & S. Gauge.

The conductivity of aluminum wire is 63% that of copper; but an aluminum wire of equivalent conductivity will have 48% of the weight and 160% of the strength.

EQUIVALENTS OF ELECTRICAL UNITS.

(Hering).

1 Kilowatt=1000 Watts.
1 Kilowatt=1.34 H.P.
1 Kilowatt=44257 foot-pounds per minute.
1 Kilowatt=56.87 B.T.U. per minute.
1 Horsepower=746 watts.
1 Horsepower=33,000 foot-pounds per minute.
1 Horsepower=42.41 B.T.U. per minute.
1 B.T.U. (British Thermal Unit) = 778 foot-pounds.
1 B.T.U.=0.2930 watt-hours.

HEAT UNITS.

(Foster.)

One pound of water evaporated from and at 212° F.	0.283 K.W. hour. 0.39 H.P. hour. 966. B.T.U. 751300. Foot-pounds. .0664 Lbs. Carbon oxidized at 100% Eff.
One pound carbon oxidized at 100% efficiency.	14,500 B.T.U. 1.11 Lbs. Anth. coal oxidized at 100%. 2.5 Lbs. Dry wood oxidized at 100%. 21 Cu. ft. Illum. Gas at 100%. 4.26 K.W. Hours at 100% Eff. 5.71 H.P. Hours at 100% Eff. 11,315,000 Foot-pounds at 100% Eff. 15 Lbs. Water evaporated at 212° F.
1 H.P. Hour.	2545 B.T.U. 0.746 K.W. hours. 1,980,000 Foot-pounds. 0.175 Lbs. Carbon oxidized at 100% Eff.

1 K.W. Hour.	.235	Lbs. Carbon oxidized at 100% Eff.
	22.8	Lbs. Water raised from 62° to 212° F.
	3.53	Lbs. Water evaporated at 212° F.
	3412	B.T.U.
	2,654,200	Foot-pounds.

CONVENIENT FORMULAE.

Hydraulics.

Lbs. per sq. in. = 0.434 times head of water in feet.
Head in feet = 2.3 × pounds per sq. in.
Weight per cu. ft. of water = 62.4 lbs.
Weight of gallon of water = 8.33 lbs.
Loss of head H due to friction in pipes.

$$H = \frac{.02 \times L \times V^2}{64.4\ D}$$

L = Length of pipe in feet; D = Diameter in feet; and V = Velocity of flow in feet per second. In calculating the total head to be pumped against, it is common to consider it equal to the sum of the friction head and the actual head.

Horse Power of Water-Fall.

$$H\ P. = \frac{62.4 \times A \times V \times H}{33{,}000}$$

A = Cross-section in sq. ft. of stream flowing over dam.
V = Velocity of flow in feet per minute.
H = Head of fall in feet.

Horse Power of Double Acting Single Cylinder Steam Engine.

$$H.P. = \frac{P \times L \times A \times N \times F}{33{,}000}$$

P = Gauge pressure at engine; L = Length of stroke in feet; A = Area of piston in square inches; N = Strokes per minute; F = Factor of cut-off found in table.

Cut-off % Stroke.	F.
1/4	.599
1/3	.670
3/8	.743
1/2	.847
5/8	.919
2/3	.937
3/4	.966
7/8	.992

APPROXIMATE AMPERES PER TERMINAL FOR ALTERNATING-CURRENT INDUCTION MOTORS.

For determining size of wires, capacity of fuses, and setting of circuit breakers.

H. P. of Motor	110 Volts		220 Volts		440 Volts		550 V.	1100 V.	2200 V.
	2 Ph.	3 Ph.	2 Ph.	3 Ph.	2 Ph.	3 Ph.	3 Ph.	3 Ph.	3 Ph.
½	3.3	3.7	1.7	1.8	.9	1.			
1	6.	6.5	3.	3.2	1.5	1.6			
2	10.5	12.	5.	6.	2.6	3.	2.5		
3	15.	17.	7.5	9.	3.8	4.5	3.5		
5	27.	30.	13.	15.	6.5	7.5	6.		
7½			20.	22.	10.	11.	9.		
10			25.	29.	12.5	14.	11.		
15			35.	41.	18.	20.	16.		
20			48.	55.	24.	27.	22.		
25			54.	62.	27.	31.	25.		
30			70.	81.	35.	40.	32.	16.	8.
40			95.	109.	47.	54.	44.	21.	11.
50			110.	127.	55.	64.	52.	27.	13.
75			165.	192.	83.	96.	77.	39.	20.
100			215.	248.	108.	124.	100.	50.	25.
150			320.	366.	160.	183.	147.	80.	40.
200			410.	475.	205.	237.	192.	98.	49.
250			510.	590.	250.	290.	237.	125.	62.
300			600.	700.	300.	350.	285.	150.	74.

For single-phase motors multiply the current per terminal for a two-phase motor by two.

SPEED CLASSIFICATIONS OF ELECTRIC MOTORS.

The electric motor may assume practically an infinite number of different forms and can be applied to an almost unlimited number of uses. Each motor, however, possesses certain inherent speed characteristics by means of which it can be classified in one of several groups. The following classification is that which was adopted by the American Association of Electric Motor Manufacturers, January, 1909:

(a) CONSTANT SPEED MOTORS in which the speed is either constant or does not materially vary, such as synchronous motors, induction motors with small slip, ordinary direct current shunt motors and direct current compound wound motors, the no load speed of which is not more than 20 per cent. higher than the full load speed.

(b) MULTISPEED MOTORS (two-speed, three-speed, etc.), which can be operate at any one of several distinct speeds, these speeds being practically independent of the load, such as direct current motors with two armature windings and induction motors with primary windings capable of being grouped so as to form different numbers of poles.

(c) ADJUSTABLE SPEED MOTORS:

(1) Shunt Wound Motors in which the speed can be varied gradually over a considerable range, but when once adjusted, remains practically unaffected by the load; such as motors designed for a considerable range of speed by field variation.

(2) Compound Wound Motors in which the speed can be varied gradually over a considerable range as in (1), and when once adjusted, varies with the load similar to compound wound constant speed motors or varying speed motors, depending upon the percentage of compounding.

(d) VARYING SPEED MOTORS or motors in which the speed varies with the load, decreasing when the load increases such as series motors and heavily compound motors. Examples of heavily compound motors are those designed for bending roll service and mill service, in which a shunt winding is provided only to limit the light load operating speed.

MOTOR DRIVEN INDUSTRIAL MACHINERY.

Electric motors are employed in practically every known industry where machinery is required. The principal advantages of electric drive are:

1. Economy in generating electric energy in large stations and distributing it over scattered areas.
2. Economy of small electric motors; power is applied at the desired points in any amount and with very small loss.
3. Facility of control; motors can be started and stopped and the speed can be adjusted with the greatest possible ease and certainty.
4. Reliability of service; motors are ready for service at any moment without any special preparation. They will work for any desired period at any load up to their full capacity and will always transform nearly all the energy they consume into useful work.
5. Flexibility of size and shape of motors and flexibility of operating characteristics. The possible variety of mechanical forms is almost unlimited, and a motor can be designed with operating characteristics to comply with any requirement.

The Westinghouse Electric & Manufacturing Company maintains several corps of engineers who make a special study of the power needs and requirements of various industries. During the many years this company has been making and applying motors a great fund of information has been gained covering almost every possible motor application. All kinds of metal working, wood working, cement, stone and clay working, textile industries, leather industries, paper making, cranes, hoists, derricks, elevators, etc., have been thoroughly studied and their power requirements are so well known that almost any problem can be readily solved. Much information along these lines is now on record in Westinghouse publications, and advice is free on any proposed motor installation.

For example, a monthly publication entitled "Machine Tool Motor Talks" will help the manager of every machine shop. Another entitled "Textile Motor Talks" contains much information of value to every textile mill official. Westinghouse Catalogue 3002-A contains sections devoted to wood-working, cement making, machine tools, textile machinery, pumping, irrigation, etc. Any one interested in any of these industries can obtain the publications illustrating and describing motor driven machines for his industry by applying to the nearest Westinghouse district office.

APPLICATION OF MOTORS TO MACHINE TOOLS.

In respect to operating speed for the most economical production, machine tools may be considered in two classes:

1. Constant speed tools, such as planers, presses, punches, grinders, etc.
2. Adjustable speed tools, such as lathes, boring, drilling, milling machines, etc.

D. C. motors can be used for either constant or adjustable speed service; hence they are applicable to either class of tools. A. C. motors are essentially constant speed machines, but can be used to drive adjustable speed machine tools through gear boxes or other mechanical speed changing devices. This latter arrangement is, however, not as convenient or durable and does not give as fine speed gradations as adjustable speed D. C. motors.

Standardization—Economy points to the fact that all machine tools in a given territory will ultimately be supplied with energy from one central station. Standardization of this energy supply and the machine tool equipment is therefore advisable.

A. C. current is preferable for distribution and A. C. motors are preferred in most cases for constant speed service. Direct current is essential for adjustable speed motors and can be obtained from the A. C. supply systems by means of motor generators or rotary converters. Three-phase, sixty-cycle alternating current is at present meeting with the most general approval for both light and power; the motors are operated at 220 and 440 volts.

Standardization of machine tool equipment will lead to improved design and lower costs. Central station power is available for break down service for shops depending on private plants; and shops with mechanical drive can make trial installations and change gradually to motor drive.

Operating Conditions—Machine tools operate very intermittently; that is, the time load factor of the average machine tool is low. Machine tool motors are, therefore, usually rated for not over two hours at full load, and hence are smaller and less expensive than motors of the same ratings for continuous service.

The ratio of the combined capacities of all the motors required for driving the tools of a shop to the total energy consumed is three or four to one where large motors drive line shafts and five or six to one where individual motors are used.

Use of the Graphic Wattmeter—With individual motor drive, the time and power required for each step of an operation can be shown by means of a graphic wattmeter. By the use of these records the following improvements can be effected:

1. All delays are revealed and measures are suggested for reducing or eliminating them.

2. The cutting rate for maximum economy can be determined for different classes of work.

3. Equitable time rates for different jobs can be established.

Economy—Maximum economy of both energy and time is usualy obtained with individual motor drive. The more important advantages of this system as compared with line shaft drive are as follows:

1. Less power required; line shaft and belt friction eliminated.

2. Time saved in setting and lining up, also in starting, reversing, and in obtaining desired speed.

3. More speeds are possible; and time is saved by obtaining the exact speed most suitable for the work.

4. Slipping and breaking of belts is eliminated; heavier cuts can be taken.

5. By the use of a graphic wattmeter causes of delay can be located without personal supervision.

6. Location of tool can be determined by sequence of operations, and changes of location can be easily made.

Economy of Continuous Operation—The savings effected by keeping the machine tool at work for the maximum possible time involves a great deal more than the saving of the workman's time. In addition to wages every shop has the following expenses:

a. Interest, depreciation, repairs and renewals of buildings and accessories.
b. General operating expenses.
c. Salaries of supervisors, engineering staff, clerks, etc.

These overhead charges are properly apportioned by setting off against each machine tool for each working hour its proportion of the overhead charges together with interest, its own cost, depreciation and cost of energy. This charge is called the "machine hour rate," and for large tools varies from about 50 cents per hour up to $5.00 per hour, depending on the size and value of the tool, the space occupied, etc.

When, therefore, individual motor drive increases the production of a machine tool by shortening the cutting time and eliminating unnecessary delays, a very considerable saving is effected.

Selection of a Motor Driven Machine Tool—In selecting a motor driven machine tool for specialized manufacturing there should be considered:

1. Exact class of work to be done.
2. Approximate feed and cutting speeds.
3. Time required to load and unload the machine.
4. Size and shape of work.

These points will enable the manufacturer of the tool to determine the rating of the motor and the type and arrangement of the controller.

SIZES OF MOTORS TO DRIVE MACHINE TOOLS.

Machine	Size	H.P. of Motor
Engine lathes, 14 to 48 in. swing....................	Light duty	2 to 7½
	Heavy duty	5 to 20
Vertical Boring Rolls.......	20 in.	5
	100 in	15
	16 ft.	30
Radial Drills..............	4 to 10 ft.	3 to 7½
Upright Drills.............	15 to 50 ft.	½ to 8
Milling Machines...........	Small	3
	Large	15
Planers	24 x 24 in.	5 to 7½
	56 x 56 in.	15 to 25
	14 x 12 ft.	75 Main Motor 12 Rail Motor
Shapers	14-36 in.	3 to 7½
Slotters	10-30 in.	3 to 15
Cold Saws................	1 to 3 ft.	2 to 10
Grinders	....	5 to 15

MOTOR DRIVEN WOOD WORKING MACHINERY.

Alternating current squirrel cage constant speed motors form the most suitable drive for the majority of wood working machines. In some few machines, as in "hogs" for reducing slabs to kindling, high flywheel effect makes starting difficult, and phase wound motors with external resistance are preferable. For machines requiring adjustable speed, such as certain types of wood lathes, direct current shunt wound motors give the best results because of the greater range of speeds possible.

Individual Motor Drive and Group Drive—Individual motor drive should be used for single machines that are operated more or less irregularly but at their full capacity. This applies to most wood working machines. Group drive is satisfactory for machines used frequently but not simultaneously. Thus an emery wheel, knife grinder, carving machine, cabinet saw and disc sander can all be run by one motor, which can have a capacity of considerably less than the aggregate ratings of the machines.

Approximate Power Required.

Machine.	Size	Motor H.P.
Jointers.	Small	2
	Large	5-7½
Inside Molders.	8 x 4	15
	15 x 6	20-30
Outside Molders.	4 x 4	5
	8 x 4	10
	14 x 5	20
Mortising Machines.		3-5
Planers, Matches and Molders.	9 x 6	30
	30 x 12	40
Surfacers	Small, slow feed	5
	Large, rapid feed	30
Belt Sanders.		3-5
Column Sanders.		3
Disc Sanders.		2

Approximate Power Required—Continued.

Machine.	Size	Motor H.P.
Drum Sanders........	16 in. drum	3
	42 in. drum	10
	60 in drum	20
	80 in. drum.	30
	102 in. drum	40
Spindle Sanders......		3
Band Saws..........	Small	3
	Large	20
Band Re-Sews........	8 x 24	15
	28 x 36	40
Circular Saws, single cut off............	14 in.	3
	36 in.	5
	60 in.	60
Circular Rip Saw....	14 in.	10
	36 in.	15
Timber Sizers.......		30-50
Tenonizing Machines..	Small	3-5
	Large	10-15

MOTOR DRIVEN PUMPS.

Both D. C. or A. C. motors are satisfactory for operating pumps. For most cases shunt wound D. C. and squirrel cage A. C. motors are suitable; but when the starting conditions are severe, as where the pump must be started against a full discharge pipe, compound wound D. C. and phase wound A. C. motors are preferable.

Power Required for Pumping—The size of motor required for operating a pump can be roughly determined by the following formula:

$$H.P. = \frac{G.P.M. \times H}{2000}$$

where G.P.M. is the gallons pumped per minute, and H is the total vertical lift in feet. This formula neglects friction head and assumes an efficiency of about 50 percent for the pumping unit.

The following formula is exact for fresh water:

$$H.P. = \frac{G.P.M. \times (H + F)}{3960 \times E}$$

Where F is the friction head and E the efficiency of the pump expressed in hundredths. For sea water, the result should be multiplied by 1.026.

Friction head depends on the speed of the water and the resistance to its flow, that is, on the condition of the interior of the pipe, the number of bends, elbows, etc. The friction head can be determined from tables in other Westinghouse publications.

DIRECT CURRENT MOTOR CONTROL.

D. C. motors are started by applying reduced voltage to the armature terminals. The speed is controlled by regulating the voltage at either the armature terminals or the shunt field terminals. The voltage is usually regulated by means of an adjustable resistance in series with the armature or the field.

Resistance in the armature circuit causes the speed to decrease; speeds above normal cannot be obtained in this manner. With armature control, the speed also varies inversely with the torque; constant speed with varying torque is therefore impossible. The loss in the resistance is large, varying with the resistance in circuit and with the square of the torque. Speed control by means of armature resistance is therefore impractical where constant speed with varying torque is required, and very uneconomical except when reduced speeds are required only for short intervals or when the torque decreases very rapidly with the speed. Armature resistance control is impractical for machine tools on account of varying speed, but is used sucessfully with the following applications:

Printing Presses,
Print Rolls,
Blowers,
Fans,
Centrifugal Pumps,
Hoists, Derricks, Cranes,
Conveyors,
Bending Rolls.

Resistance in the shunt field circuit causes the motor speed to increase; speeds below normal cannot be obtained in this manner. The speed of a shunt wound motor remains practically constant at all field adjustments, regardless of torque. Shunt field control is therefore the ideal method of speed adjustment for machine tool motors.

The speed of a compound wound motor operating with weakened shunt field varies inversely with the torque, the extent of the variation depending on the resistance in the shunt field circuit. Great care must be used not to weaken the shunt field excessively when a compound wound motor is operating with varying torque, otherwise the removal of the load may cause the motor to race and be ruined.

SOME IMPORTANT INSTALLATIONS OF WESTINGHOUSE MOTORS FOR DRIVING MAIN ROLLS IN STEEL PLANTS.

Kind and Size of Mill	Name of Plant	Motor.			
		H.P.	R.P.M.	Voltage	Type
Light Rail	Carnegie Steel Co.	1500	100-125	220	D.C. Comp. Wd., two units
Light Rail	Illinois Steel Co.	1800	80-120	2200	HF induction, two units of two motors each in cascade
30-in. Plate	Illinois Steel Co.	4000	0-150	575	D.C. Shunt Wd., two units reversing
Sheet Mill	Seneca I. & S. Co.	1200	240	440	HF Induction
18-in. Merchant	Indiana Steel Co.	3200 650	91 184	6600	HF Induction
14-in. Merchant	Indiana Steel Co.	3200 650	91 184	6600	HF Induction
12-in. Merchant	Indiana Steel Co.	2000 650	113 210	6600	HF Induction
12-in. Merchant	Indiana Steel Co.	2500	92-113	6600	2-speed, HF Induction
10-in. Merchant	Indiana Steel Co.	2000	113-163	6600	2-speed, HF Induction
Skelp	National Tube Co.	2500	184	6600	HF Induction, ten motors of size given
16-in. Merchant	Cambria Steel Co.	1000	184	2200	HF Induction
Roughing Train	Am. Steel & Wire Co.	2600	815	6600	HF Induction
Finishing Train	Am. Steel & Wire Co.	1600	500	6600	HF Induction
Finishing Train	Am. Steel & Wire Co.	1300	500	6600	HF Induction
Roughing Rolls	Illinois Steel Co.	3000	91	2200	HF Induction
Finishing Rolls	Illinois Steel Co.	1000	133	2200	HF Induction
Sheet Mill	Am. Rolling Mill	1500	210	2200	HF Induction

METER TESTING,

With Portable Standard Watthour Meter.

Formerly the method of calibrating watthour meters by the use of indicating wattmeters and stop-watches was standard. Formulae given with each make of meter, provided means for translating the readings of the meters and stop-watches into percent accuracy. This method is described in the succeeding pages.

The increasing use of electric current has made necessary a cheaper, more convenient and accurate method of testing. This need has been entirely met by the Westinghouse Portable Standard Watthour Meter. The method gives percent accuracy of the house meter directly by comparing the disk speeds of the two meters.

On the next four pages is given a table of the relative speeds of various makes of meters and percent accuracy for use in testing with the Westinghouse Portable Watthour Meter. As an example,—if it is desired to test a Westinghouse 5-ampere 100-volt wattmeter, using the above standard,—the two meters are connected with their current coils in series and shunt coils in parallel and loaded so as to give for light load 1 revolution of the disk of the service meter in approximately 1 minute, and for full load 25 revolutions in the same time. The Westinghouse Portable Standard can be started and stopped instantly by means of a push button switch connected in the shunt circuit. The test is made by noting the number of revolutions made by the portable standard while the service meter under test makes its normal one-minute run (in this case, 1 revolution for light load and 25 revolutions for full load). The number of revolutions made for these two loads by the standard, if the service meter is correct, would be 1 and 25 respectively. If the number of revolutions made by the standard is 1.03, service meter is 3% slow, and if the number of revolutions is .97 service meter is 3% fast at light load. From this example, it will be seen that the accuracy of any meter listed can be determined directly from the table for any speed within 6% fast or slow without any calculation whatever. The Portable Standard Watthour Meters are made in both single-phase and polyphase styles. A polyphase service meter can be tested with a single-phase standard, however, by testing each side as a single-phase element and multiplying the disk revolutions of the standard by 2.

Calibration Data for Testing Induction Watthour Meters with Westinghouse Standard Portable Watthour Meter.

Make		Service Meter			Stan'd Meter	Revolutions of Westinghouse Portable Integrating Wattmeter for 94% to 106% Registration of Service Meter												
		Cap. Amps.	Revs. Heavy Load	Revs. Light Load	Cap. Amps.	94 %	95 %	96 %	97 %	98 %	99 %	100 %	101 %	102 %	103 %	104 %	105 %	106 %
*Westinghouse	Types B and C	5 10 20 40	25 25 25 25	... ...	5 10 20 40	26.6	26.32	26.04	25.77	25.51	25.25	**25.00**	24.75	24.51	24.27	24.04	23.81	23.58
		5 10 20 40	... ...	1.0 1.0 1.0 1.0	5 10 20 40	1.06	1.05	1.04	1.03	1.02	10.1	**1.00**	.99	.98	.97	.96	.95	.94
		80 80	15 ...	... 1.0	40 40	31.91 2.13	31.58 2.11	31.25 2.08	30.93 2.06	30.61 2.04	30.3 2.02	**30.00** **2.00**	29.70 1.98	29.41 1.96	29.13 1.94	28.85 1.92	28.57 1.90	28.30 1.89
Gen. Electric	Type I	3 3	30 ...	... 2.0	5 5	19.15 1.28	18.95 1.26	18.75 1.25	18.56 1.24	18.37 1.22	18.18 1.21	**18.00** **1.20**	17.82 1.19	17.65 1.18	17.48 1.17	17.31 1.15	17.14 1.14	16.98 1.13
		5 10	30 30	... ...	5 10	28.72	28.42	28.13	27.84	27.55	27.27	**27.00**	26.73	26.47	26.21	25.96	25.71	25.47
		5 10	... ...	2.0 2.0	5 10	1.92	1.90	1.88	1.86	1.84	1.82	**1.80**	1.78	1.77	1.75	1.73	1.71	1.70
		15 15	30 ...	... 2.0	20 20	23.93 1.60	23.68 1.58	23.44 1.56	23.20 1.55	22.96 1.53	22.73 1.52	**22.50** **1.50**	22.28 1.49	22.06 1.47	21.84 1.46	21.63 1.44	21.43 1.43	21.23 1.42

Calibration Data for Testing Induction Watthour Meters with Westinghouse Standard Portable Watthour Meter.

Make	Service Meter			Stan'd Meter	Revolutions of Westinghouse Portable Integrating Wattmeter for 94% to 106% Registration of Service Meter												
	Cap. Amps.	Revs. Heavy Load	Revs. Light Load	Cap. Amps.	94%	95%	96%	97%	98%	99%	100%	101%	102%	103%	104%	105%	106%
G. E. Type I	25 50	30 30	... ...	20 40	35.90	35.53	35.16	34.80	34.44	34.09	**33.75**	33.42	33.09	32.77	32.45	32.14	31.84
	25 50	... ...	2.0 2.0	20 40	2.39	2.37	2.34	2.32	2.30	2.27	**2.25**	2.23	2.21	2.18	2.16	2.14	2.12
Fort Wayne Type K	5 10 40	30 30 30	... ...	5 10 40	23.93	23.68	23.44	23.20	22.96	22.73	**22.50**	22.28	22.06	21.84	21.63	21.43	21.23
	5 10 40	... ...	2.0 2.0 2.0	5 10 40	1.60	1.58	1.56	1.55	1.53	1.52	**1.50**	1.49	1.47	1.46	1.44	1.43	1.42
	25 50	30 30	... ...	20 40	23.93	23.68	23.44	23.20	22.96	22.73	**22.50**	22.28	22.06	21.84	21.63	21.43	21.23
	25 50	... ...	2.0 2.0	20 40	1.60	1.58	1.56	1.55	1.53	1.52	**1.50**	1.49	1.47	1.46	1.44	1.43	1.42

It is recommended test be made at approximately 100% and 4% of full load if loads are within range of standard meter. Load service meter so as to give revolutions stated in table in approximately one minute. Where possible capacity of coils used should be same for both service and standard meters. *Westinghouse Round Pattern and type "A" meters make fifty r.p.m. at full load. Speeds given are for 100-110 volt meters. If 200-220 volt meters are tested use 200 volt coil of standard meter, and speeds still apply. This data does not apply on General Electric Co. Type I-40 cycle meters.

Calibration Data for Testing Commutator Type A.C. Watthour Meters with Westinghouse Standard Portable Watthour Meter.

	Service Meter			Standard Meter Amp. Cap.	REVOLUTIONS OF WESTINGHOUSE PORTABLE WATTHOUR METER FOR 94 PER CENT TO 106 PER CENT REGISTRATION OF SERVICE METER													WATT HRS. PER REV.	
	Amp. Cap.	Revolutions			94 Per Cent	95 Per Cent	96 Per Cent	97 Per Cent	98 Per Cent	99 Per Cent	100 Per Cent	101 Per Cent	102 Per Cent	103 Per Cent	104 Per Cent	105 Per Cent	106 Per Cent	Service Meter	*Standard Meter
		Heavy Load	Light Load																
General Electric Forms J, JN, J-1, FN, DN, D-1	3	30	...	5	19.15	18.95	18.75	18.56	18.37	18.18	18.0	17.82	17.65	17.48	17.31	17.14	16.98	0.2	0.333
		...	3	5	1.92	1.9	1.87	1.86	1.84	1.82	1.8	1.78	1.76	1.75	1.73	1.71	1.7		
	5	15	...	5	23.94	23.67	23.44	23.20	22.96	22.73	22.5	22.28	22.06	21.85	21.63	21.43	21.[illegible]	0.5	0.333
		...	2	5	3.19	3.16	3.13	3.1	3.06	3.03	3.0	2.97	2.94	2.91	2 89	2.86	2.[illegible]		
	10	30	...	10	23.94	23.67	23.44	23.20	22.96	22.73	22.5	22.28	22.06	21.85	21.63	21.43	21.23	0.5	0.666
		...	3	10	2.39	2.37	2.34	2.32	2.3	2.27	2.25	2.23	2.2	2.18	2.16	2.14	2.12		
	15	30	...	20	23.94	23.67	23.41	23.20	22.96	22.73	22.5	22.28	22.06	21.85	21.63	21.43	21 23	1.0	1.333
		...	3	20	2.39	2.37	2.44	2.32	2.3	2.27	2.25	2.23	2.2	2.18	2.16	2.14	2.12		
	25	30	...	20	23.94	23.67	23.44	23.20	22.96	22.73	22.5	22.28	22.06	21.85	21.63	21.43	21 23	1.0	1.333
		...	3	20	2.39	2.37	2 34	2.32	2.3	2.27	2.25	2.23	2.2	2.18	2.16	2.14	2.12		
	50	30	...	40	23.94	23.67	23.44	23.20	22.96	22.73	22.5	22.28	22.06	21.85	21.63	21.43	21.23	2.0	2.666
		...	3	40	2.39	2.37	2.34	2.32	2.3	2.27	2.25	2.23	2.2	2.18	2.16	2.14	2 12		

Speeds given are for 100-110 volt meters.
If 200-220 volt meters are tested use 200 volt coil of standard meter and speeds still apply.

Calibration Data for Testing Commutator Type A.C. Watthour Meters with Westinghouse Standard Portable Watthour Meter.

	Service Meter			Standard Meter Amp. Cap.	Revolutions of Westinghouse Portable Watthour Meter for 94 Per Cent to 106 Per Cent Registration of Service Meter													Watt Hrs. Per Rev.	
	Amp. Cap.	Revolutions			94 Per Cent	95 Per Cent	96 Per Cent	97 Per Cent	98 Per Cent	99 Per Cent	100 Per Cent	101 Per Cent	102 Per Cent	103 Per Cent	104 Per Cent	105 Per Cent	106 Per Cent	Service Meter	*Standard Meter
		Heavy Load	Light Load																
General Electric Forms J-2 and D 2	3	50	...	5	19.94	19.74	19.58	19.33	19.13	18.94	18.75	18.56	18.38	18.20	18.03	17.85	17.68	0.125	0.333
		...	5	5	1.99	1.97	1.95	1.93	1.91	1.89	1.87	1.86	1.84	1.82	1.80	1.78	1.77		
	5	40	...	5	25.53	25.26	25.00	24.74	24.49	24.24	24.0	23.76	23.53	23.3	23.08	22.86	22.64	0.2	0.333
		...	4	5	2.65	2.53	2.5	2.47	2.45	2.42	2.4	2.38	2.35	2.33	2.31	2.29	2.26		
	10	40	...	10	25.53	25.26	25.00	24.74	24.49	24.24	24.0	23.76	23.53	23.3	23.08	22.86	22.64	0.4	0.666
		...	4	10	2.55	2.53	2.5	2.47	2.45	2.42	2.4	2.38	2.35	2.33	2.31	2.29	2.26		
	15	50	...	20	23.94	23.67	23.44	23.20	22.96	22.78	22.5	22.28	22.06	21.85	21.63	21.43	21.23	0.6	1.333
		...	5	20	2.39	2.37	2.34	2.32	2.3	2.27	2.25	2.23	2.2	2.18	2.16	2.14	2.12		
	25	40	...	20	31.91	31.58	31.25	30.93	30.61	30.3	30.0	29.7	29.41	29.13	28.85	28.57	28.3	1.0	1.333
		...	4	20	3.19	3.16	3.13	3.09	3.06	3.03	3.0	2.97	2.94	2.91	2.89	2.86	2.83		
	50	40	...	40	31.91	31.58	31.25	30.93	30.61	30.3	30.0	29.7	29.41	29.13	28.85	28.57	28.3	2.0	2.666
		...	4	40	3.19	3.16	3.13	3.09	3.06	3.03	3.0	2.97	2.94	2.91	2.89	2.86	2.83		

Speeds given are for 100-110 volt meters.
If 200-220 volt meters are tested use 200 volt coil of standard meter and speeds still apply.

METER TESTING

With Portable Wattmeter.

SHALLENBERGER AMPERE HOUR METER.

Note the number of revolutions made by the small "tell-tale" index of the register dial, in a number of seconds, using the following formula:

$$\frac{\text{No. of Rev. x Meter Constant}}{\text{No. of Sec.}} = \text{Current.}$$

If, therefore, the index of a 20 ampere meter makes 19 revolutions in 120 seconds the current passing is:

$$\frac{19 \times 63.3}{120} = 10 \text{ amperes.}$$

This may be checked by means of a portable ammeter and the percentage fast or slow determined.

The cover should be left on the meter while these readings are taken.

The constants of the different capacity meters are given below:

Meter Capacity	Calibrating Constant
5 ampere	22.5
10 "	33.3
20 "	63.3
40 "	126.6
80 "	253.1
120 "	336.
160 "	506.

SHALLENBERGER AND WESTINGHOUSE WATTHOUR METERS.

The standard formula for testing all types and capacities, when using indicating standards and stop watches, is Watts $= \frac{R}{T} K$ in which:

R = Number of complete revolutions in time T.

T = Time in seconds required for revolutions R.

K = Constant.

The constant K varies with different types and capacities as outlined below:

Shallenberger, Westinghouse Round Pattern Back Connected and Type "A" Single-Phase Watthour Meters.

2-Wire Meters

For self-contained meters

K = volts x amps. x 1 .2.

For meter used with current transformer only (but checked without)

K = volts (as marked on dial) x 6.

For meters used with current and voltage transformers (but checked without)

K = 600.

For meters used with transformers of either or both forms (and checked with)

K = volts x amps. x 1 .2.

3-Wire Meters.

For self-contained meters

K = volts x amps. x 2.4.

For meters used with current transformers only (but checked without)

K = volts x 6.

Type A Polyphase Watthour Meters.

For self-contained meters

K = volts x amps. x 2.4.

For meters used with current transformers only (but checked without)

K = volts x 12.

For meter used with current and voltage transformers (but checked without)

K = 1200.

For meters used with transformers of either or both forms (and checked with)

K = vols x amps. x 2.4.

Note:—In all cases the volt and ampere values are those marked on meter. The full load speed of all these meters is 50 R.P.M.

Types B and C Single-Phase Watthour Meters.

2-Wire Meters.

For self-contained meters

K = volts x amps. x 2.4.

For meters used with current transformers only (but checked without)

K = volts x 12.

For meters used with current and voltage transformers (but checked without)

K = 1200.

For meters used with transformers of either or both forms (and checked with)

K = volts x amps. x 2.4.

3-Wire Meters.

For self-contained meters

K = volts x amps. x 4.8.

For meters used with current transformers (but checked without)

K = volts (as marked on meter) x 12.

Note:—In all cases the volt and ampere values are those marked on meter. The full

PER CENT ERROR TABLE FOR FIFTHS OF A SECOND.

The table given below will be found convenient in showing the per cent fast or slow which a meter is running when employed in conjunction with the following formula:

$$\frac{\text{Watts Constituting Load}}{\text{Testing Constant x 60}} = \text{Rev. Per Min.}$$

This formula shows the number of revolutions the meter should make in one minute at full load. By noting the time actually required to make this number of revolutions and referring to the table the percentage of error is quickly found.

Time in Seconds.	Per Cent.	
56.60	6.01	Fast.
.80	5.63	
57.00	5.26	
.20	4.89	
.40	453	
.60	4.17	
.80	3.81	
58.00	3.45	
.20	3.09	
.40	2.74	
.60	2.39	
.80	2.04	
59.00	1.69	
.20	1.35	
.40	1.01	
.60	0.67	
.80	0.33	
60.00	0.00	
60.20	0.33	Slow.
.40	0.67	
.60	0.99	
.80	1.31	
61.00	1.63	
.20	1.96	
.40	2.27	
.60	2.59	
.80	2.91	
62.00	3.22	
.20	3.53	
.40	3.84	
.60	4.15	
.80	4.45	
63.00	4.76	
.20	5.06	
.40	5.36	
.60	5.66	
.80	5.95	
64.00	6.25	

load speed of Types "B" and "C" meters is 25 R.P.M.

Type C Polyphase Watthour Meters.

For self-contained meters

$$K = \text{volts} \times \text{amps.} \times 4.8.$$

For meters used with current transformers only (but checked without)

$$K = \text{volts} \times 24.$$

For meters used with current and voltage transformers (but checked without)

$$K = 2400.$$

For meters used with transformers of either or both forms (and checked with)

$$K = \text{volts} \times \text{amps.} \times 4.8.$$

Note:—In all cases the volt and ampere values are those marked on meter. The full load speed of Type "C" Polyphase meters is 25 R.P.M.

CURRENT PER PHASE IN VARIOUS SYSTEMS.

$I = \dfrac{W}{E \times P.F.}$ for single-phase circuit.

$I = 0.50 \times \dfrac{W}{E \times P.F.}$ for two-phase circuit.

$I = 0.58 \times \dfrac{W}{E \times P.F.}$ for three-phase circuit.

I = Current in line in amperes; W = energy delivered in watts; E = potential between mains in volts; P.F. = power factor. When power factor cannot be accurately determined it may be assumed as follows: Lighting load with no motors, 0.95; lighting load and motors, 0.85; motors only, 0.80.

CENTIGRADE AND FAHRENHEIT SCALES.

Temperature Centigrade	Temperature Fahrenheit	Temperature Centigrade	Temperature Fahrenheit
0	32	50	122
5	41	55	131
10	50	60	140
15	59	65	149
20	68	70	158
25	77	75	167
30	86	80	176
35	95	85	185
38	100.4	90	194
40	104	95	203
42	107.6	100	212
45	113		

Temp. C. = 5/9 (Temp. F.—32.)
Temp. F. = 9/5 Temp. C.+32.

ELECTRIC HEATING APPARATUS.

The regular line of heating apparatus now manufactured by the Westinghouse Electric and Manufacturing Company includes devices used for domestic cooking, laundry, hat manufacturing, confectionery, printing and publishing, and various other purposes.

For confectioners, chocolate warmers or dippers are made in standard sizes for capacities of twenty-five and forty pounds, requiring fifty and sixty watts, respectively. Batch warmers, spinning heaters, candy heaters, kettles, revolving pans, beating machines, and other devices used by confectioners, can be supplied on special order.

Hat factories employ electric brim heaters, curling machines, hand shells, ovens, flanging bags, hand and machine irons, straw hat flats, printing and embossing heads, and velouring and curling stoves. The watt consumption of these varies from one hundred fifty to six hundred fifty. The use of electric heaters improves the quality of the work done, and increases the capacity of the machines.

For use in laundries, there is carried a complete line of sad irons ranging in size from three to nine pounds; polishing irons in five, six, and seven and one-half pound sizes; and for use on very heavy laundry work a thirty-pound drag iron.

For the printing and publishing trades the Westinghouse Company carries a complete line of glue pots and glue cookers, and is prepared to equip special glueing devices with electric heaters. Press heads and press blocks are special, and information will be supplied on any type desired. Electric palette and hand-tool heaters, which hold a large number of tools, and which vary in power consumption from three hundred and fifty to fifteen hundred watts, according to size, are also made up on special order.

Electrically heated matrix driers have been supplied for a number of large newspapers and have fully demonstrated that the time required to dry a single matrix may be cut down to less than three minutes. The best with steam or gas heaters is from five to six minutes.

For eletrotypers and stereotypers there are furnished wax kettle heaters, wax trimming knives, case warmers, and sweating-on tables. For photo-engravers, burning-in stoves, rotary drier heaters, negative drying cabinets, evaporating dish heaters, etc., are supplied on special order.

Tailors' goose irons are carried in stock in sizes from twelve to twenty-four pounds, in both the narrow and the wide type patterns, consuming from seven hundred to eight hundred fifty watts. Another line of tailors' machine irons consists of the above mentioned narrow type goose irons arranged for use in connection with pressing machines. In addition to the above there is a wide type goose iron in sixteen and eighteen pound sizes for use on an automatic stand. The arrangement is such that the iron takes power from the circuit only when it is resting on the stand.

Luminous-type radiators are made with two, three or four heating units, each unit taking two hundred and fifty watts. Non-luminous air heaters are made with two, three, four, five or six heating units, each unit taking five hundred watts.

Electrically heated stoves are carried in stock in four and six-inch sizes, consuming two hundred and five hundred watts, respectively. The Westinghouse electric toaster-stove is available for light cooking operations requiring a hot surface. It consumes five hundred watts.

TO FIND AMPERES PER PHASE

Three-Phase Circuits.

Power Factor.

Volts.			100%	90%	80%	70%
110	Kw	x	5.256	5.84	6.57	7.51
220	Kw	x	2.628	2.92	3.28	3.75
370	Kw	x	1.562	1.735	1.952	2.231
380	Kw	x	1.521	1.690	1.900	2.170
390	Kw	x	1.482	1.646	1.852	2.117
440	Kw	x	1.314	1.460	1.640	1.877
550	Kw	x	1.050	1.166	1.312	1.500
1100	Kw	x	.5256	.584	.657	.751
2200	Kw	x	.2628	.292	.328	.375
2400	Kw	x	.2400	.266	.3000	.342
3300	Kw	x	.1750	.1944	.2187	.250
6600	Kw	x	.0875	.0972	.1093	.125
10000	Kw	x	.0578	.0640	.0722	.0825
13200	Kw	x	.0438	.0486	.0546	.0625
16500	Kw	x	.0350	.0388	.0437	.0500
22000	Kw	x	.0263	.0292	.0328	.0375
33000	Kw	x	.0175	.0194	.0219	.0250

Two-Phase Circuits.

110	Kw	x	4.54	5.04	5.67	6.48
220	Kw	x	2.27	2.52	2.83	3.24
440	Kw	x	1.13	1.26	1.41	1.62
1100	Kw	x	.454	.504	.567	.648
2200	Kw	x	.227	.252	.283	.324

Single-Phase Circuits.

110	Kw	x	9.09	10.01	11.36	12.98
220	Kw	x	4.54	5.05	5.68	6.49
440	Kw	x	2.27	2.52	2.84	3.24
1100	Kw	x	.909	1.01	1.136	1.298
2200	Kw	x	.454	.505	.568	.649

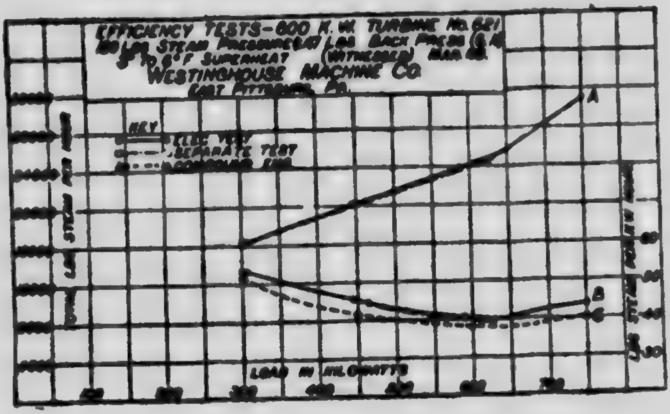

Figure 1.

A—total water per hour 120 lbs. ga. steam pressure, non-condensing 7 lbs. ga. back pressure.

B—pounds steam per kw. hr. same conditions. Point of change in curvature of lines A and B, show when overload valve begins to operate.

C—pounds steam per kw. hr. compound engine. Note that turbine performance under most unfavorable conditions is within 5 percent of engine performance.

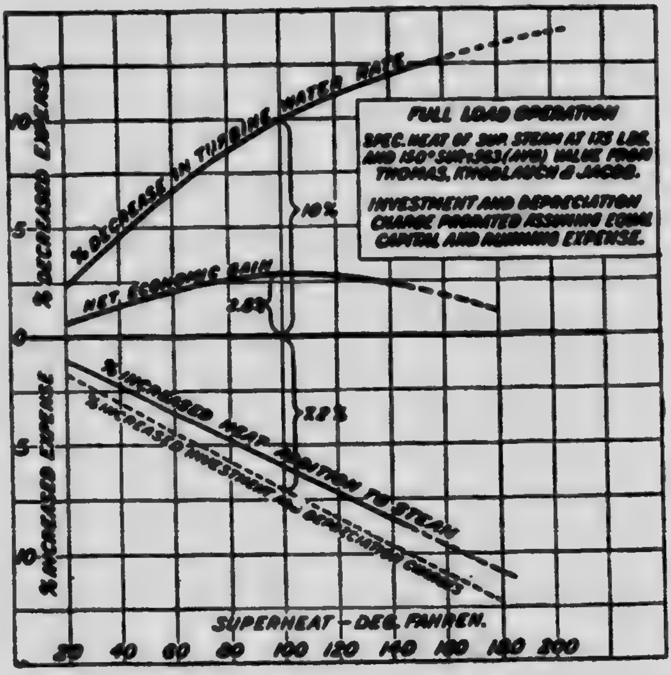

Figure 2.

Fig. 2.—Net improvement in plant efficiency with varying degrees of superheat.

It will be recognized that as the degree of superheating is increased, the steam consumption of the prime mover is proportionally decreased. Other factors which are effected in obtaining this superheat are generally overlooked and the idea is more or less prevalent that the plant efficiency steadily increases with the superheat. A study of the conditions, however, demonstrates that the improvement ceases at about 100 degrees superheat, the point of flexure in the curve of net economic gain.

In some types of turbines a high degree of superheat is essential to delay the dew point and obviate the effect of moist steam.

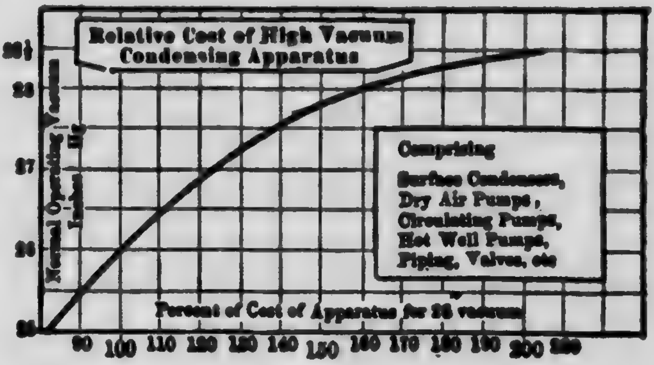

Figure 3.

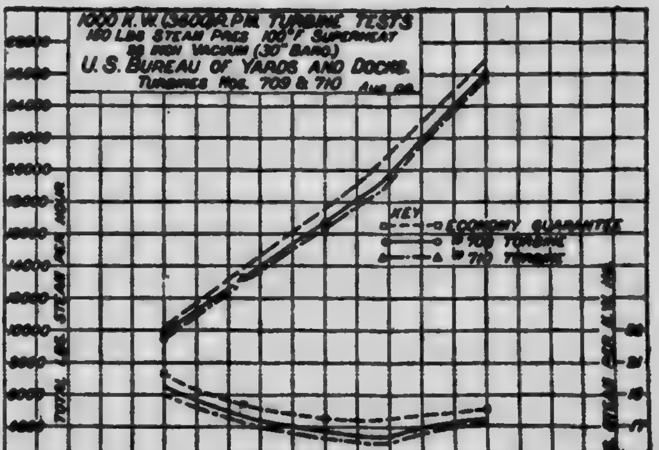

Figure 4.

SPECIAL STEAM TURBINE APPLICATIONS.

Low Pressure Turbine.

The term low pressure turbine refers to turbines which utilize exhaust steam at about atmospheric pressure, by expanding it to a lower pressure maintained by means of a condenser. Steam at atmospheric pressure is available for use in turbines in nearly all steel mills, mines and in many light and railway plants originally designed to operate noncondensing. As the low pressure turbine utilizes exhaust steam, the power generated is obtained practically without cost. It does not increase the steam consumption of the main engine and therefore does not require the expenditure of more fuel, although capable of developing from 80% to 100% of the power obtained from the high pressure reciprocating engine.

The only costs chargeable against the low pressure turbine are interest, depreciation and maintenance of the turbine and condensing apparatus. They therefore furnish the most economical method of increasing plant capacity where the main engines are operated noncondensing, or for furnishing power for live rolls or lighting in rolling mills and mines where the exhaust steam from rolling mill or hoisting engines is available.

Where the exhaust steam from a single engine running intermittently such as in hoisting, is to be used for operating a low pressure turbine, continuous operation of the latter is made possible by use of a steam regenerator or heat storage reservoir, which consists of a plain cylindrical tank partly filled with water which condenses the excess exhaust not used by the turbine when the engine is running, and re-evaporates it owing to a slight drop in pressure in the regenerator when the supply of engine steam is deficient. A rolling mill engine or hoisting engine will have a steam consumption of approximately 40 lbs. per indicated H.P., whereas the low pressure turbine will generate a kilowatt hour for approximately 30 lbs. of steam at full load. Hence, a 500 H.P. hoisting engine operating half the time is capable of driving a 325 Kw. generator continuously without requiring any extra coal. In large plants having a number of noncondensing engines, the installation of a central low pressure turbine plant with the exhaust lines from the isolated engines all discharging into a single header in the station, the average flow will be sufficiently uniform that the heat storing capacity of the exhaust mains may be sufficient, thus rendering a regenerator unnecessary.

January, 1911.

450

N 5739 [illegible] [illegible]

SUN. 1

New Year's Day

[illegible]

MON. 2

21387 — 82700 —

[illegible] —

86.600

23391

-82

[illegible]

25391

86

TUES. 3

— 11th Con [illegible]

[illegible] McDougall

[illegible] —

[illegible] Booth [illegible]

½ mile from station

[illegible] Sta

WED. 4

THUR. 5

3.58

[illegible]

[illegible] 95 [illegible]

[illegible]

FRI. 6

Epiphany

292

584

146

296

592

1776

SAT. 7

January, 1911.

SUN.
8
1st Sunday after Epiphany

[illegible]

MON.
9

[illegible]

7/8 — [illegible] [illegible]

[illegible]

TUES.
10

R [illegible]

3 [illegible]

[illegible] 7

WED.
11

[illegible]

THUR.
12

[illegible]

FRI.
13

19.75 — 1 [illegible]

20 [illegible]

19. [illegible]

SAT.
14

B7 [illegible]

January, 1911.

[illegible]

SUN. 15

2nd Sunday after Epiphany

45 3/4 [illegible]

MON. 16

TUES. 17

48
17

" 1x5 [illegible]
1 " 1x4 green
1 " 1x5 green
2 " 1x5 dry
2 " 1x4 not to go
7 " 1x4

34

WED. 18

112

211

6 pcs 1x10+12
3 - 1x5 + up
4 1x6
2 1x8

THUR. 19

68

24

FRI. 20

153

5 bdls 2" 28
6 " 1½" 84
2 " 1" 30
2 x 12 142
60

SAT. 21

January, 1911.

SUN. 22
R Dolahan
[illegible]
3rd Sunday after Epiphany
St Paul 6 ar 14868 – 1980 [illegible]

MON. 23
Sat night [illegible] 12 o'clock
Mrs R[illegible] [illegible]

TUES. 24
[illegible] 2 Indian Red
Boulange
Bedon house Peterhead

WED. 25
bag gen 4 Indian & white
6 ar 28611 [illegible] 2950 5.
1 St Mn 17½ Indian 1 white

THUR. 26
[illegible]
6 ar 7 4 2 [illegible]
6 Turkey [illegible]

FRI. 27

83 551 4 4

SAT. 28
4914 Georgia Turkey
[illegible] 50

January, 1911.

SUN.
29
4th Sunday after Epiphany

6 [illegible] 1½ for Sunday

MON.
30

[illegible] - [illegible]
Newstyle
Filing cabinet
engineer
[illegible]

TUES.
31

[illegible] Short [illegible] [illegible]

WED.
1

February.

Hrs	Guns		
8	7½	Sausage	.56
7	6½		
9	7		

THUR.
2

Grand + Joy
[illegible] [illegible] [illegible] —
12^{00} or 7^{50} + Duty +
A.T. ribbon 1^{00} each

FRI.
3

SAT.
4

February, 1911.

SUN. Eyre 5 8 [illegible] Jessemer St
5 [illegible] of Rawamost
5th Sunday after Epiphany

Ferguson
[illegible] 14 [illegible] 12 tons on [illegible]
[illegible] of fuel
20.

MON.
6

J Stuart Ferguson
Colonial Bldg
Bay & King
Toronto

TUES.
7

See Bill & WK
WED. for Pulling in fire
8

See Bill ties Long
Lake

THUR.
9 + Lumber at Scott Dam
from Greenbeyer letter

See about Spruce on 2 3 [illegible]
FRI.
10 from Government
Cedar [illegible] Price [illegible]

SAT. [illegible]
11

February, 1911.

[illegible] man [illegible]

X [illegible] 2 [illegible]

SUN.
12

Septuagesima   Lincoln's Birthday

[illegible]

[illegible] [illegible]

MON.
13

[illegible] 1

[illegible]

TUES.
14

DL&W 32457

14402 – [illegible] –

WED.
15

BR&P 4405
12 10.6

THUR.
16

FRI.
17

SAT.
18

February, 1911

SUN.
19
Sexagesima

Kennedy
4 x 7 bed _ 8 ft
17 12

MON.
20 [illegible] 2 x 7
[illegible]

Dach #8

TUES.
21

Pumps _

---

write Dunn re

WED.
22
Washington's Birthday

# 2 + # 3 Norway
Lath
Both 1 car #1 white 2 cars #3

THUR.
23

9c 9 [illegible]

	wh p	ft	Hem ft
Midland -	2512 ·	92,579	76 ; 3127
Small Bay	172	6,778	7 184

FRI.
24

40 M 2 Cattle Cars
38 M [illegible]
14 M at [illegible]

SAT.
25

E. [illegible]
[illegible]
[illegible]

February, 1911.

R Laidlaw

1/2 2 x 6 22.00

1/2 2 x 8 23.00

SUN. 26

Quinquagesima

Take Balance If all right

[illegible] to sample

Lay Box out close

MON. 27

[illegible]

[illegible]

Order Wire #6

TUES. 28

1/2 ton [illegible]

WED. 1

March.

Ash Wednesday

THUR. 2

v ft

1998 66.58

140 4.816

63061 - 4TR 13338

FRI. 3

11065 NUC.

SAT. 4

Cart # 6 [illegible]

March, 1911.

SUN.
5
1st Sunday in Lent

1400 7908
600 5" [illegible]
8 lbs 50# [illegible]
60 "

MON.
6

51 • 50# 6 Dr [illegible]

---

10 r 300 300
60
TUES. 2 350
7
182
12 45 [illegible] 45 82
92 [illegible]

WED.
8

f. [illegible] 300 lbs
6 [illegible] 500 lb

THUR. [illegible] [illegible] 510 lbs
9

95 bags [illegible] 6053

FRI. 15½ cords R [illegible]
10
246 DYS 98773 [illegible] 18500 ft
Adams 7 crates [illegible] [illegible]

SAT. 105097 Eric
11
42 - 1/2 98 - 3/8 170 - 9/16

March, 1911.

[illegible] Rip

SUN.
12
2nd Sunday in Lent

[illegible]

[illegible]

MON.
13

20 [illegible] 1x [illegible]

[illegible] in [illegible]

[illegible]

TUES.
14

49 1800 | 90x220
200 [illegible] 2
Bia 18[illegible] –

WED.
15

THUR.
16

FRI.
17

SAT.
18

Lent

March, 1911

SUN.
19
bal 33351 CRRCW
37 Bells

3rd Sunday in Lent

1 to 12
19 Bell
72

71

MON.
20 bal 15912 S C RR

[illegible]
1,750 Bad
36.000
9 @ 4
13 @ 4
11 @ 4
8 @ 4
7 @ 4
4 @ 4
25
60 m [illegible]

TUES.
21

bal [illegible] 12 [illegible] 64.71

WED.
22
1 to 70 piles
[illegible] = 60

THUR.
23
Foryladee
Lorene scarf Monday

bal 577809 [illegible]

1st [illegible]
[illegible] 600 68

FRI.
24
72012 CRR

bal 64978

SAT.
25
1 to 70

March, 1911.

[illegible] [illegible] have [illegible]
at [illegible]

SUN. 26
4th Sunday in Lent

7 T. [illegible]
[illegible] [illegible] Mi
[illegible] Men Kotchen

MON. 27

TUES 28

Bridge jasper + [illegible]
Box 1448 [illegible]

BW 1279 [illegible]
[illegible] [illegible]

WED. 29

order flowers

THUR. 30

[illegible]
64710 6 M + St P

Mc [illegible] card fr
19 [illegible]
72 [illegible]
7833 [illegible]
[illegible]

FRI. 31

SAT. 1
April.

26 ft 24" d 30

Sat Apl 20 **April, 1911.**

SUN. Sat [illegible] Lalonde off

2 [illegible]

5th (Passion) Sunday in Lent [illegible] 6 men

[illegible]

MON. [illegible]

3 [illegible] Joe Desjardin [illegible]

[illegible] + [illegible]

[illegible] [illegible]

TUES. [illegible] whalen house

4

Monday apl [illegible]

[illegible] 3 men

[illegible] [illegible] Robins [illegible]

WED. [illegible]

5 [illegible] Lalonde [illegible]

[illegible] Bourgoin [illegible]

[illegible] 3903 [illegible]

THUR. [illegible]

6

161 [illegible] 1 80 [illegible]

3 men —

FRI. — 483 [illegible]

7

— 1 [illegible] —

SAT.

8

April, 1911.

[illegible]

SUN.
9
Palm Sunday

[illegible]

MON.
10

Jim william

15 [illegible]
5 + x 7

TUES.
11

WED.
12

THUR.
13

FRI.
14

SAT.
15

April, 1911.

SUN.
16
Easter Day

MON.
17

TUES.
18

WED.
19

THUR.
20

FRI.
21

SAT.
22

SUN.
23
1st Sunday after Easter

MON.
24

TUES.
25

WED.
26

THUR.
27

FRI.
28

SAT.
29

SUN.
30
2nd Sunday after Easter

MON.
1

May.

TUES.
2

WED.
3

THUR.
4

FRI.
5

SAT.
6

May, 1911.

SUN.
7
3rd Sunday after Easter

MON.
8

TUES.
9

WED.
10

THUR.
11

FRI.
12

SAT.
13

SUN.
14
4th Sunday after Easter

MON.
15

TUES.
16

WED.
17

THUR.
18

FRI.
19

SAT.
20

SUN.
21
Rogation Sunday

MON.
22

TUES.
23

WED.
24

THUR.
25
Ascension Day

FRI.
26

SAT.
27

May, 1911.

SUN.
28
Sunday after Ascension

MON.
29

TUES.
30
Decoration Day

WED.
31

THUR.
1 June.

FRI.
2

SAT.
3

June, 1911.

SUN.
4
Whitsunday

MON.
5

TUES.
6

WED.
7

THUR.
8

FRI.
9

SAT.
10

June, 1911.

SUN.
11
Trinity Sunday

MON.
12

TUES.
13

WED.
14

THUR.
15

FRI.
16

SAT.
17

SUN.
18
1st Sunday after Trinity

MON.
19

TUES.
20

WED.
21

THUR.
22

FRI.
23

SAT.
24

June, 1911.

SUN.
25
2nd Sunday after Trinity

MON.
26

TUES.
27

WED.
28

THUR.
29

FRI.
30

SAT.
1 July.

July, 1911.

SUN.
2
3rd Sunday after Trinity

MON.
3

TUES.
4
Independence Day

WED.
5

THUR.
6

FRI.
7

SAT
8

SUN.
9
4th Sunday after Trinity

MON.
10

TUES.
11

WED.
12

THUR
13

FRI.
14

SAT.
15

July, 1911.

SUN.
16
5th Sunday after Trinity

MON.
17

TUES.
18

WED.
19

THUR.
20

FRI.
21

SAT.
22

July, 1911.

SUN.
23
6th Sunday after Trinity

MON.
24

TUES.
25

WED.
26

THUR.
27

FRI.
28

SAT.
29

SUN.
30
7th Sunday after Trinity

MON.
31

August.

TUES.
1

WED.
2

THUR.
3

FRI.
4

SAT.
5

August, 1911.

SUN.
6

Transfiguration. 8th Sunday after Trinity

MON.
7

TUES
8

WED
9

THUR
10

FRI.
11

SAT.
12

August, 1911.

SUN.
13
9th Sunday after Trinity

MON.
14

TUES
15

WED.
16

THUR.
17

FRI.
18

SAT.
19

August, 1911.

SUN.
20
10th Sunday after Trinity

MON.
21

TUES.
22

WED.
23

THUR.
24

FRI.
25

SAT.
26

August, 1911.

SUN.
27
11th Sunday after Trinity

MON.
28

TUES.
29

WED.
30

THUR.
31

FRI.
September. **1**

SAT.
2

September, 1911.

SUN.
3
12th Sunday after Trinity

MON.
4
Labor Day

TUES.
5

WED.
6

THUR.
7

FRI.
8

SAT.
9

September, 1911.

SUN.
10
13th Sunday after Trinity

MON.
11

TUES.
12

WED.
13

THUR.
14

FRI.
15

SAT.
16

September, 1911.

SUN.
17
14th Sunday after Trinity

MON.
18

TUES.
19

WED.
20

THUR.
21

FRI.
22

SAT.
23

September, 1911.

SUN.
24
15th Sunday after Trinity

MON.
25

TUES.
26

WED.
27

THUR.
28

FRI.
29

SAT.
30

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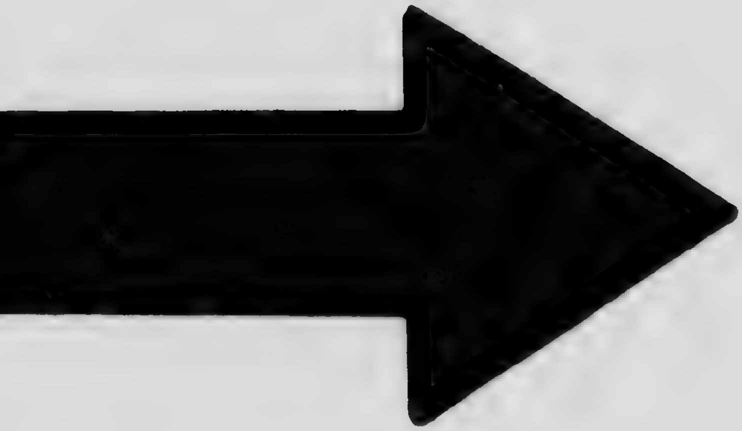

MICROCOPY RESOLUTION TEST CHART

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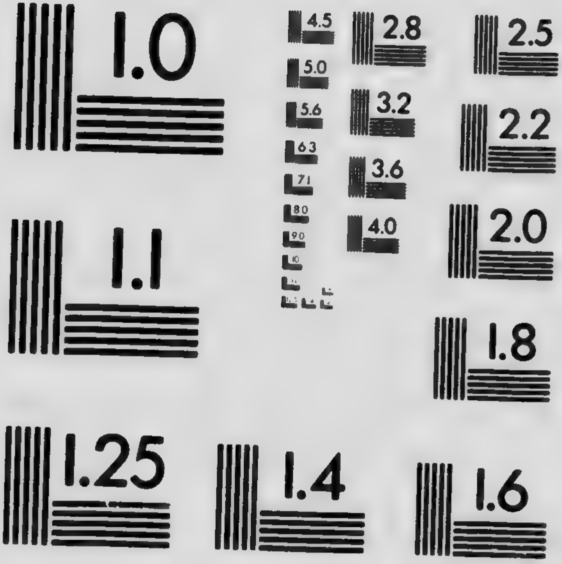

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(716) 482 - 0300 - Phone
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October, 1911.

SUN.
1
16th Sunday after Trinity

MON.
2

TUES.
3

WED.
4

THUR
5

FRI.
6

SAT.
7

SUN.
8
17th Sunday after Trinity

MON.
9

TUES.
10

WED.
11

THUR.
12

FRI.
13

SAT.
14

October, 1911.

SUN.
15
18th Sunday after Trinity

MON.
16

TUES.
17

WED.
18

THUR.
19

FRI.
20

SAT.
21

October, 1911.

SUN.
22
19th Sunday after Trinity

MON.
23

TUES.
24

WED.
25

THUR.
26

FRI.
27

SAT.
28

October, 1911.

SUN.
29
20th Sunday after Trinity

MON.
30

TUES.
31

WED.
1 November.
All Saints

THUR.
2

FRI.
3

SAT.
4

November, 1911.

SUN.
5
21st Sunday after Trinity

MON.
6

TUES.
7

WED.
8

THUR.
9

FRI.
10

SAT.
11

November, 1911.

SUN.
12
22nd Sunday after Trinity

MON.
13

TUES.
14

WED.
15

THUR.
16

FRI.
17

SAT.
18

November, 1911.

SUN.
19
23rd Sunday after Trinity

MON.
20

TUES.
21

WED.
22

THUR.
23

FRI.
24

SAT.
25

November, 1911.

SUN.
26
Sunday next before Advent

MON.
27

TUES.
28

WED.
29

THUR.
30
Thanksgiving Day

FRI.
1 December.

SAT.
2

SUN.
3
1st Sunday in Advent

MON.
4

TUES.
5

WED.
6

THUR.
7

FRI.
8

SAT.
9

December, 1911.

SUN.
10
2nd Sunday in Advent

MON.
11

TUES.
12

WED.
13

THUR.
14

FRI.
15

SAT.
16

SUN.
17
3rd Sunday in Advent

MON.
18

TUES.
19

WED.
20

THUR.
21

FRI.
22

SAT.
23

December, 1911

SUN.
24
4th Sunday in Advent

MON.
25
Christmas Day

TUES.
26

WED.
27

THUR.
28

FRI.
29

SAT.
30

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May 1st

Memoranda.

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80
40

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395
17[illegible]

365

EXPENSE REPORT

Date	From	To	R. R Fare		Sleeper		Hotel		Bus Bag.		Phone		St. Car Pos&Tel		Miscellaneous Items		

EXPENSE REPORT

Date	From	To	R. R Fare		Sleeper		Hotel		Bus Bag.		Phone		St. Car Pos&Tel		Miscellaneous Items		

EXPENSE REPORT

Date	From	To	R. R Fare		Sleeper		Hotel		Bus Bag.		Phone		St. Car Pos&Tel		Miscellaneous Items		

EXPENSE REPORT

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EXPENSE REPORT

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EXPENSE REPORT

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EXPENSE REPORT

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EXPENSE REPORT

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EXPENSE REPORT

Date	From	To	R. R Fare	Sleeper	Hotel	Bus Bag.	Phone	St. Car Pos&Tel	Miscellaneous Items

EXPENSE REPORT

Date	From	To	R. R Fare		Sleeper		Hotel		Bus Bag.		Phone		St. Car Pos&Tel		Miscellaneous Items		

EXPENSE REPORT

Date	From	To	R. R Fare		Sleeper		Hotel		Bus Bag.		Phone		St.Car Pos&Tel.		Miscellaneous Items		

EXPENSE REPORT

Date	From	To	R. R Fare		Sleeper		Hotel		Bus Bag.		Phone		St. Car Pos&Tel		Miscellaneous Items		

REDUCTION GEAR.

Melville-Macalpine.

As turbines inherently involve high rotative speed, many applications necessitate the use of reduction gears. High speed reduction gears have been satisfactorily employed in sizes of 300 H.P. and less, for a number of years, in which balanced helical gears placed in solid bearings were used. High powers were impractical in this type of gear, due to troubles from excessive tooth pressure arising from wear of the bearings and maladjustments.

In the Melville-Macalpine "gear" these difficulties are obviated by the use of a floating frame on which the pinion is carried. The frame which is supported on a flexible "I" beam is free to oscillate in a vertical plane, automatically maintaining an even distribution of tooth pressures. High efficiencies obtain in this gear, and during an official test of a 6000 H.P. set, 98.5% was secured over a wide range in load. It was primarily devised for marine practice to permit the turbine and propeller to be operated at their most efficient speed. It also has been adopted for driving large direct current generators which must be driven at relatively low speeds to avoid commutation troubles. Reductions of one to twelve may be readily obtained. Other uses in driving pumps and shafting may be made.

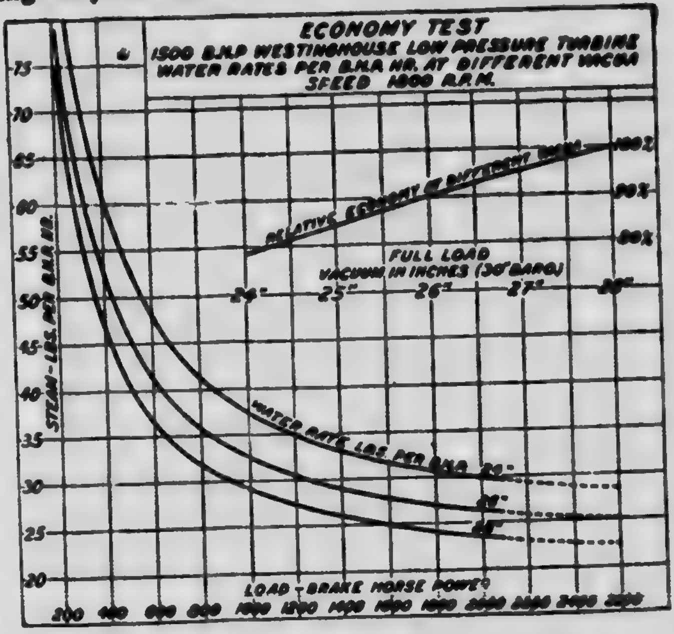

Figure 5.

Fig. 5.—Economy of a 1000 Kw. Westinghose low pressure turbine with vacuum varying from 24" to 28".

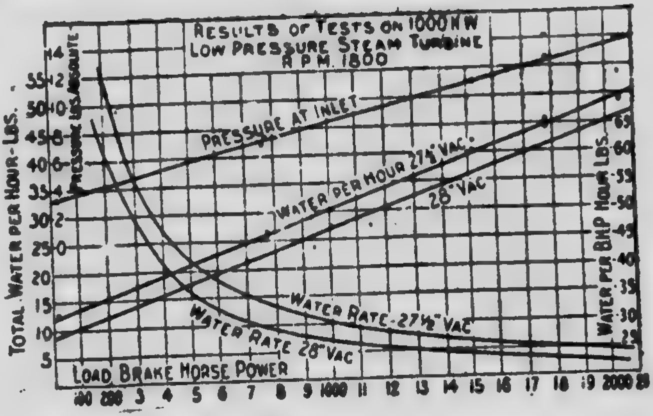

Figure 6.

Fig. 6 shows the results of tests upon a 1000 Kw. Westinghouse low pressure double flow steam turbine operating on dry saturated steam. The economy at maximum load and 28 inch vacuum, is 22 lbs. per b.h.p. hour with steam at an initial pressure of 13.8 lbs. absolute. This corresponds to a steam consumption of about 32 lbs. per Kw. hour.

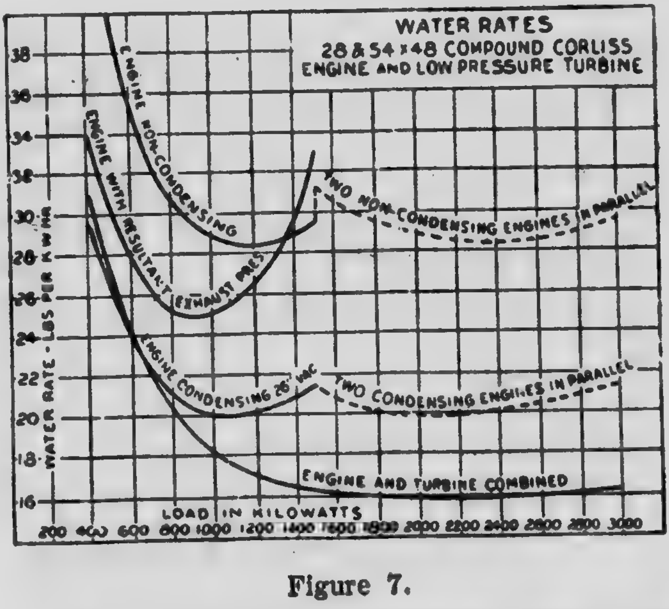

Figure 7.

Fig. 7 shows the combined water rate curve for a cross-compound Corliss condensing engine and low pressure turbine. An examination of these curves will show that approximately 75% more power is obtained for a given amount of steam when the engine is run noncondensing and the exhaust used in a low pressure turbine, than when the engine is run condensing without the turbine. This demonstrates the economy of installing noncondensing engine and low pressure turbine in place of a condensing reciprocating engine, as the combined unit has a smaller initial cost per Kw. output, than the condensing engine. As the engine and turbine can be electrically tied together, a governor on the low pressure turbine is generally unnecessary.

High Pressure Turbine.

Steam turbines designed for noncondensing operation are eminently suited for service in central stations operating district heating systems, owing to their great overload capacity and flat water rate curve.

In many locations condensing water is scarce, or can be obtained only by the use of cooling towers, and in such cases plants suitably located near business or residential districts, a very substantial return on the investment can be obtained by selling the exhaust steam at from 40 to 60c per thousand pounds, whereas with coal at $4.00 per ton, the cost of generating a thousand pounds of live steam is but 25c. The loss by condensation in steam pipes properly laid and protected, will not exceed from 6 to 10% per mile of pipe. A back pressure of from 1 to 6 lbs. is all that need be carried for satisfactory service. Some plants employ a vacuum return system having no back pressure on the engines.

An alternative to straight noncondensing is furnished by the bleeder system, in which the steam for heating is taken from the second barrel of a condensing turbine (equivalent to running noncondensing) and all the steam not required for heating, condensed after passing through the low pressure section of the turbine. This system insures maximum economy under all conditions, as there is no waste of steam, it either being sold for heat or used in the low pressure section for generating power. Such a plant is in successful operation at Adrian, Mich., using Westinghouse turbines.

As an example of what can be done by district heating, we may cite the case of a Railway Lighting and Heating Company. One year of operation, the returns from the heating system were sufficient to pay the coal bill for the entire year, interest and maintenance of the underground system and power house pay roll; the income from the lighting and railway power business being profit, with the exception of the interest and depreciation charges on power house investment.

Turbo Pumps and Blowers.

A wide field for the application of steam turbines has been opened up by the improvements in centrifugal pumps and turbo blowers. Centrifugal pumping machinery driven by turbines is now available for all moderate and high head work, such as municipal pumping stations, fire systems, fire boats, boiler feeding, mining and many other industries where large volumes of water must be pumped against a high head. Noncondensing, a duty of 35 to 45 million ft.-lbs. per 1000 lbs. of steam can be obtained, or 70 to 90 million ft.-lbs. per 1000 lbs. of steam when running condensing. When the difference in maintenance, oil required, valve renewals and sustained efficiency of the turbine-driven pump is capitalized, the turbine pump is on a par with other types of pumping engines in regard to cost, but has the additional advantages of being incapable of pumping against a head much exceeding that for which it is designed, thus avoiding the danger of bursting the pipes when the delivery is shut off, and of being able to meet a great increase in capacity without change of speed when the pressure is slightly reduced. This latter characteristic in the noncondensing field makes the turbine driven pump unexcelled for hydraulic elevator service. In steel works where large quantities of water must be pumped against considerable head, centrifugal pumps driven by exhaust steam (low pressure) turbines, are particularly advantageous and will show large returns on the investment. The same applies to mining where turbine driven centrifugal pumps are available for draining the mine, using exhaust steam from the hoisting engines. Exhaust steam turbine driven fans can also be used for ventilation, these being the most reliable, compact and efficient ventilating devices in existence.

For all purposes where air is required at a pressure of from 2 to 15 lbs. per sq. in., centrifugal turbine-driven blowers are available at an economy equal to that of blowing engines, but requiring but a very small portion of the floor space and costing but a small fraction of reciprocating blowers.

The theoretical water horspower required to raise A gallons of water per minute to a height of H feet is.................. $WHP = \frac{A \times H}{4000}$

and the brake horse power actually required will be................ $HP = \frac{A \times H}{2500}$

This allows for efficiency of pump and a considerable margin of safety.

SMALL TURBINES.

Turbines designed for capacities of 200 kw. and less may be correctly classed as small machines. Steam turbines came rapidly into prominence in the last decade, mainly through the development of the larger sizes. This course was evidently logical, as it was with the large reciprocating engines that limitations were first encountered. As the same advantages of decreased oil consumption, floor space, maintenance and attendance over the reciprocating engine similarly exists in small turbines, these machines have been since designed for all uses fulfilled by the steam engine for slow speed operation. Slow speed may be obtained through reduction gears. Where an economical speed may be employed, the steam consumption of the small turbine is practically on a parity with an efficient engine, as the following table indicates:

Kw. Rating	STEAM CONSUMPTION 150 lbs. Ga. Non Cond.		
	Lbs. Kw. Hr.	Lbs. B.H.P. Hr.	Lbs. Equivalent I.H.P. Hr.*
25	72.7	51	44
50	62	43.5	38.2
100	50	35	31.6

---

*These values are approximate, depending upon speed employed, and it should be borne in mind that the efficiency of the turbine is sustained over long periods while the engine is subject to rapid decline in efficiency, due to inadjustment and valve leakage.

Owing to operating with constant angular velocity, the small turbine is particularly desirable for lighting sets, exciters and boiler feeds, centrifugal pumps and compressors.

EFFECT OF VACUUM ON TURBINE ECONOMY.

In Fig. 8 the results of 20 to 40 tests on 500 Kw. Westinghouse-Parsons turbines are given, showing the total water and water rate per b.h.p. hour for various vacua from 25 to 29 inches. These are all from tests at the vacua

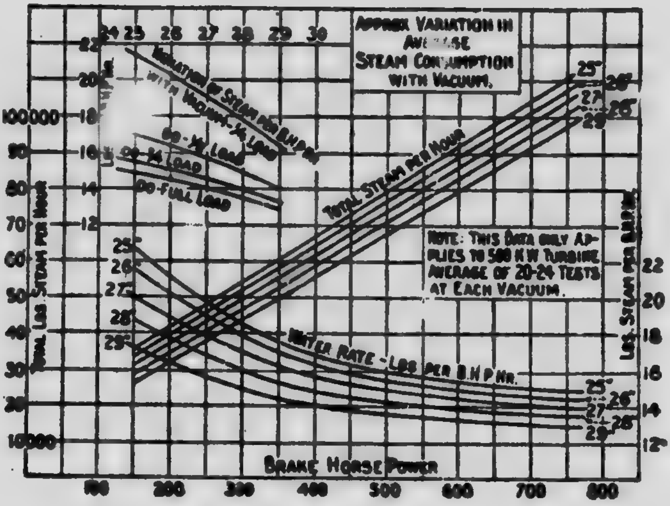

Figure 8.

stated, with dry steam, and were not obtained by correction. Correction factors deduced from Fig. 8 have been plotted in Fig. 9, taking a 28" vacuum as the standard. In order to reduce the steam consumption at 27 inches to 28 inches, it is only necessary to multiply by the corresponding factor, .963 at full load, or .953 at half load.

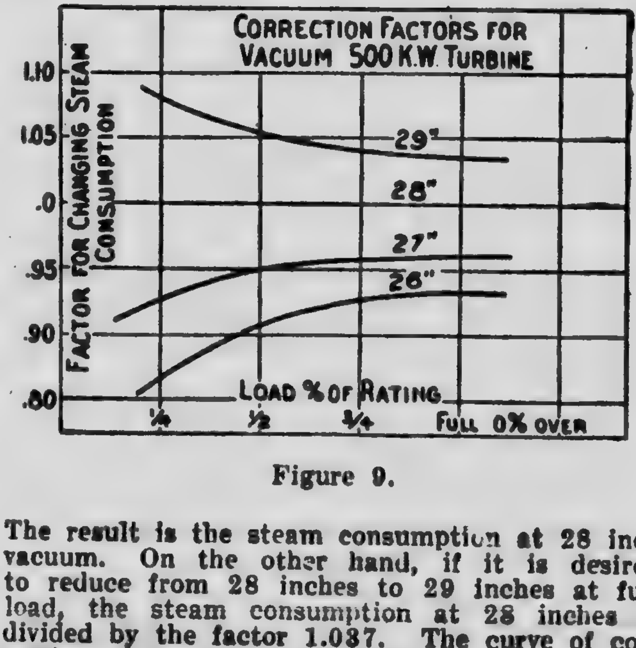

Figure 9.

The result is the steam consumption at 28 inch vacuum. On the other hand, if it is desired to reduce from 28 inches to 29 inches at full load, the steam consumption at 28 inches is divided by the factor 1.037. The curve of correction factors is only strictly true for 500 Kw. turbines, but it is also approximately correct for normally rated turbines of larger size.

An important point to be noted in these results is that Westinghouse-Parsons turbines may be operated with good efficiency on moderate, low vacuum, or even noncondensing. Thus, a water rate of 13.6 lbs. per b.h.p. hr. on 28 inches vacuum, full load, is increased by only 1.4 lbs. to 15 lbs. when under 25 inches vacuum. This is an advantage peculiar to the Parsons or pressure type turbine, and renders plant economy less sensitive to deficient operating conditions.

LEBLANC CONDENSERS.

The Leblanc condenser is of the counter flow jet type, equipped with a centrifugal discharge pump and a special form of centrifugal jet air pump capable of handling large volumes of air and the maintenance of a vacuum corresponding to within two degrees of the temperature in the condenser. The air and circulating pump which are on the same shaft, are driven by the same motor, steam engine or steam turbine, which, operating at a high speed, makes the most compact high vacuum apparatus possible. Its special advantages consist in its ability to work with a very much smaller terminal difference than other types of condensers, frequently maintaining the ideal vacuum even with comparatively warm condensing water, or in cases where the temperature rise is high due to the limited quantity of condensing water available.

Tests—Leblanc Condenser.

70° Water.

Approximate rating....	44%	70%	95%
Steam per hour, lbs...	13100	21100	28750
Ratio water to steam.	82.5	51.4	45.8
Temp. diff. vac. and discharge, Deg. F...	6	7	8.5
Power required, e.h.p..	52	53	56
Temp. injection, Deg..	65	70	71
Vacuum carried.......	28.76	28.09	27.96
Per cent. perfect vac..	99.1	98.6	99.16

Approximate rating....	....	123%	148%
Steam per hour, lbs....	....	37000	44400
Ratio water to steam..	....	33.0	24.9
Temp. diff. vac. and disch, Deg. F.......	....	2	4
Power required, e.h.p..	....	55	51
Temp. injection, Deg. F.	....	70	70
Vacuum carried.......	....	27.59	26.81
Percent perfect vacuum.	....	99.15	98.48

Cooling Water Required for Condensing.

The curves as drawn show the theoretical ratio of cooling water to steam condensed, assuming zero temperature difference. To use these curves with any given temperature difference, it is only necessary to add this difference to the inlet temperature; e. g., inlet temperature, 70 deg.; vacuum, 28 inches; temperature difference, 10 deg. From the curve, the water ratio for 80 deg. and 28 inch vacuum is 44.0. Conversely, if the maximum water ratio available is known, and its temperature, the possible vacuum can be found, or having the water ratio and vacuum, the necessary inlet temperature can be determined.

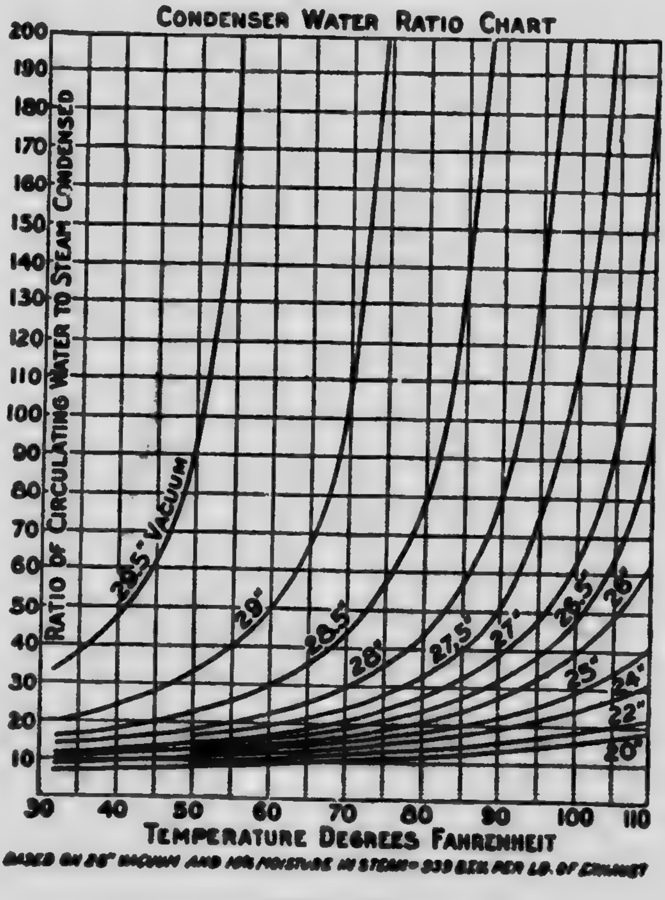

Figure 10.

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WESTINGHOUSE GAS ENGINES.

Horizontal Double-Acting Type—Fractional Load Tests.

Test of 500 H.P. Westinghouse Gas Engine.—Norton Co., Worcester, Mass.

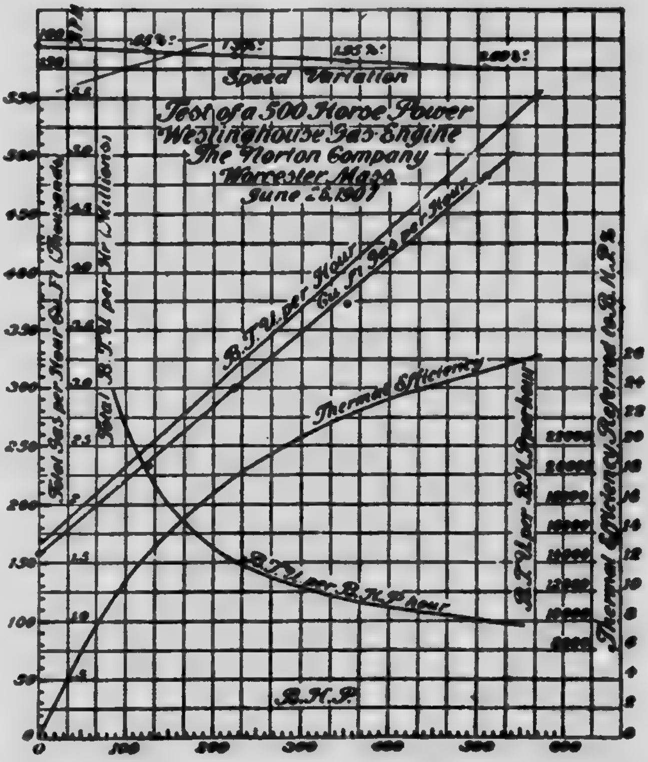


Figure 11.

From report—A. S. M. E. 1907 Holder Drop Method. Bituminous Producer Gas.

Typical Efficiency Tests, Single-Acting Gas Engines. Average of three tests, 19x22-300 H.P. Engines.

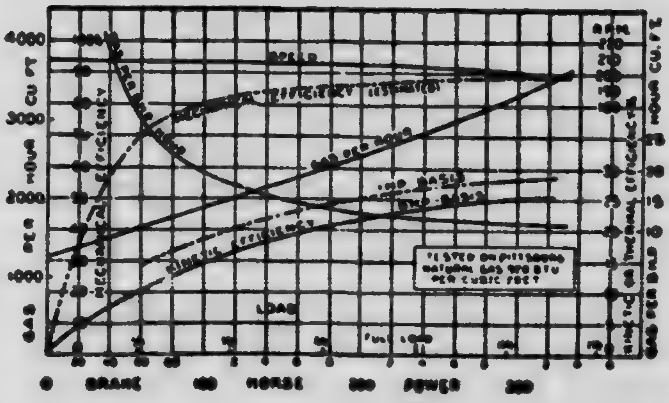


Figure 12.

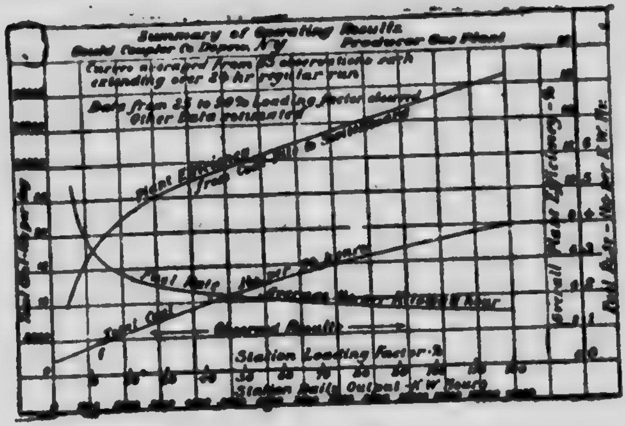


Figure 13.

These curves, Figs. 11, 12 and 13, show the general performance and efficiencies that may be expected from the type of engine tested, viz., the Westinghouse four-cycle single acting multi-cylinder. The expression "kinetic efficiency," means the ability of the engine to convert heat into useful work; in other words, the percent of the original heat sent to the engine which finally appears at the shaft. An efficiency of 26 percent at full load has been obtained under more favorable conditions. The efficiency of the ordinary steam engine of equal size seldom exceeds one-half that shown by these gas engines.

Formula = Thermal or kinetic efficiency =2545 ÷ Btu per h.p. per hour.

Method of Determining Comparative Cost of Gas and Steam Power for Assumed Conditions. 5000 Kw. Station—66 Percent Loading Factor.

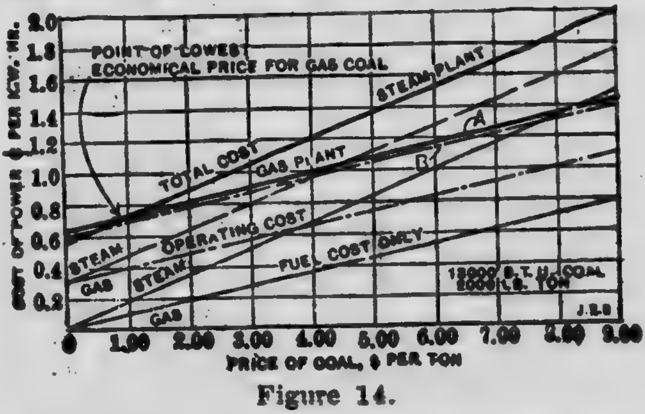


Figure 14.

Note—Operating cost includes fuel, labor, supplies, repairs. Total cost includes operating and fixed costs. Curve "A" for gas engine costing $40 B.H.P. Curve "B" for gas engine costing $80 per B.H.P.

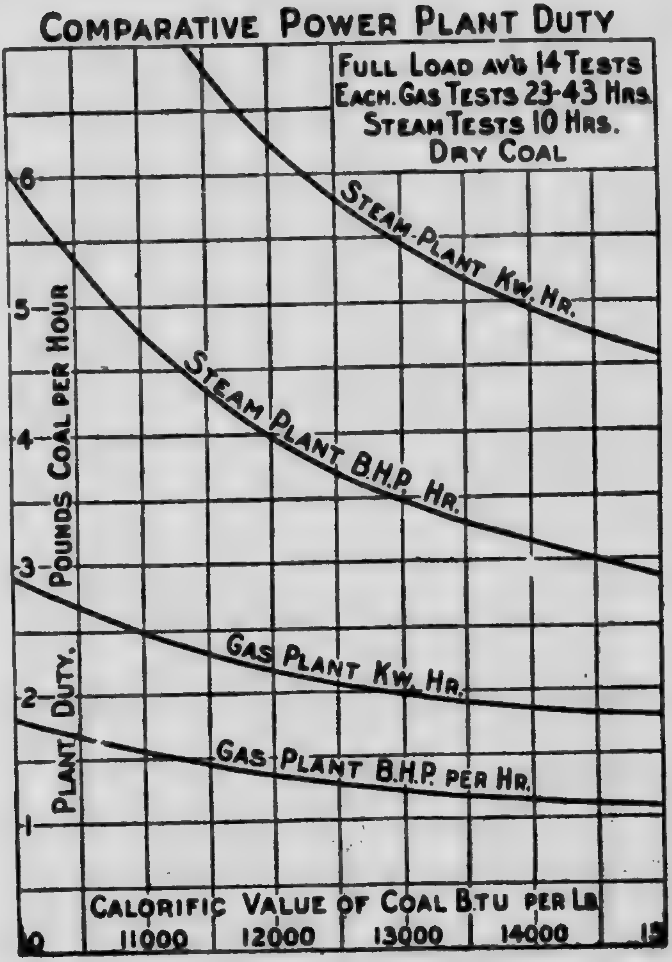


Figure 15.

Operating Costs 800 H.P. Gas Power Station Using Natural Gas.

Westinghouse Triple Cylinder Vertical Gas Engines, Belted Generators.

Station capacity (five engines) kilowatts	470
Number of years in operation........	8.5
Average station load factor ('03-'06) percent	19.09
Average gas consumption per kilowatt hour ('03-'06) (cu. ft.)..........	25.5
Average heat efficiency at switchboard (percent)	14.14

Cost of Power.

	Dollars per year avg. 8 yr.	Cents pr. kw. hr. avg. 4 yr.
Fuel gas, including heating	8121	0.307
Station wages...........	3068	0.410
Oil waste and supplies...	454	0.054
Running repairs.........	848	0.085
Running repairs gas engines only	285	0.034
Total operating costs..	$7776	0.890

Engine repairs, $0.36 per horse power per year.

Engine repairs, .57 per engine per year.

Engine repairs, .75 percent on investment.

Fuel—Bradford Natural Gas.

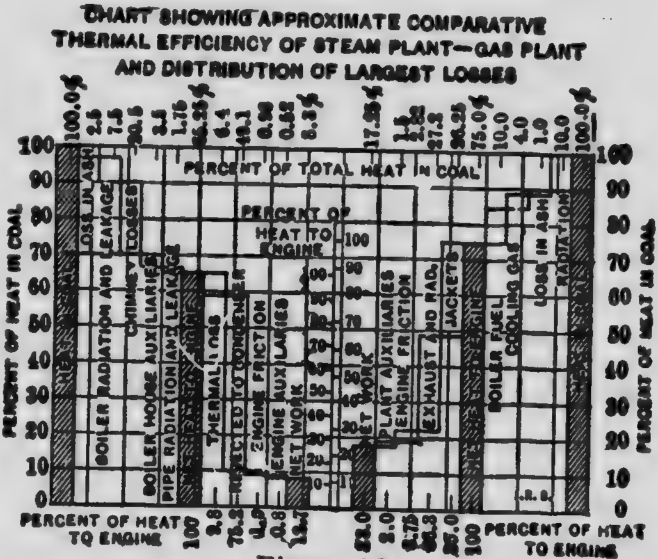


Figure 16.

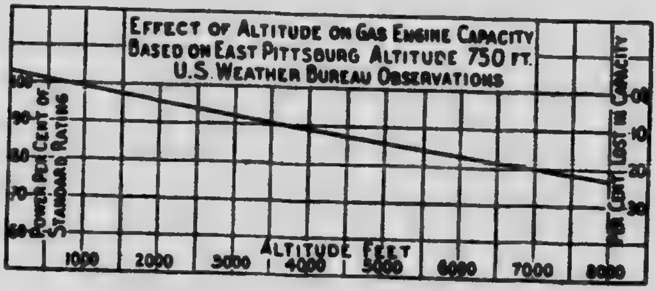


Figure 17.

COMMERCIAL POWER GASES—TYPICAL ANALYSIS.

NAME OF GAS (Calculated by J. R. Bibbins)	CONSTITUENTS—PER CENT BY VOLUME									Heat Value		Air (Theoretical) required for complete Combustion
	Hydrogen	Methane	Carbon Monoxide	Illuminant (Ethylene)	Total Combustible	Carbon Dioxide	Nitrogen	Oxygen	Total Incombustible	Net or Effective	Mixture Net.	
DESIGNATION	H	CH_4	C O	C_2H_4	%	CO_2	N	O	%	B.t.u. pr. Cu. Ft.		Cu. Ft.
Natural Gas	3	92	0	3	98	0	2	0	2	967.2	93.8	9.31
Oil Gas (Distillate)	32	48	0	16.5	96.5	0	3	0.5	3.5	772	88.5	7.725
Coal Gas (Bench or Retort)	46	40	6	5	97	0.5	2	0.5	3	585.6	86.2	5.792
Crude Oil Water Gas	46	26	6	10	88	8	3.5	0.5	12	543.1	86.9	5.708
Coke Oven Gas	50	36	6	4	96	1.5	2	0.5	4	545.2	85.8	5.358
Water Gas (Carburetted)	40	25	19	8.5	92.5	3	4	0.5	7.5	526.5	87.45	5.02
Water Gas (Blue)	48	2	38	0	88	6	5.5	0.5	12	279.1	86.1	2.245
Producer Gas (Bituminous)	13	5	15	0.2	33.2	7.3	59	0.5	66.8	131.2	60.25	1.178
" " (Mond)	27.5	2	11	0	40.5	16.5	42.5	0.5	59.5	129.8	61.7	1.105
" " (Anthracite)	15	2.5	20	0	37.5	8	54	0.5	62.5	127.5	61.5	1.075
" " (Wood)	14	2	20	0.2	36.2	16.3	47	0.5	63.8	125	61.5	1.038
" " (Coke)	10	0	29	0	39	4.5	56	0.5	61	122.1	63.3	0.932
Air Gas (Blast Furnace)	2.5	0	25	0	27.5	11.5	61	0	72.5	88.7	53.5	0.675

PROXIMATE ANALYSES AND HEATING VALUE OF SOME AMERICAN COALS.

(Authority Geo. L. Fowler.)		Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Heating Value per lb. B.T.U.	Rel. Htg. Value based on Pochnts. 100.
Anthracite,	South Field, Pa.,	3.09	4 28	83.81	8.18	.64	13 220	88.
Semi-Anthracite,	Bernice Basin,	.65	9.40	83.69	5.34	.91	13.700	91.
Semi-Bituminous,	Clearfield Co., Pa.,	.76	22.52	71 82	3.99	.91	14.950	99.
	Cumberland, Md.,	1.09	17.30	73.12	7.75	.74	14.400	96.
	Pocahontas, Va.,	1.00	21.00	74.39	3.03	.58	15.070	100.
Bituminous,	Connellsville, Pa.,	1.26	30.12	59.61	8.23	.78	14.050	93.
	Pittsburg, Pa.,	1.37	35.90	52.21	8.02	1.80	13.410	89.
	Thacker, W. Va.,	1.38	35.04	56.03	6.27	1.28	14.040	93.
	Hocking Valley, O.,	6.59	34.97	48.85	8.00	1.59	12.130	81.
	Scott Co., Tenn.,	1.26	35.76	53.14	8.02	1.80	13.700	91.
	Jefferson Co., Ala.,	1.55	34.44	59.77	2.62	1.42	13 770	91.
	Big Muddy, Ill.,	7.50	30.70	53.80	8.00	–	12 420	82.
	Mt. Oliver, Ill.,	11.00	35.65	37.10	13.00	–	10.490	69.
	Missouri,	6.44	37.57	47.94	8.05	–	12.230	81.
Lignite,	Iowa,	8.45	37.09	35.60	18.86	–	8.720	58.
	Utah,	9.29	41.97	45.37	3.20	1.18	11.030	73.

FEATURES OF THE RONEY MECHANICAL STOKER.

Over one million four hundred thousand h.p. sold.

All largest power stations in New York City fired by Roney Stokers.

All parts of grate interchangeable.

No bolts inside furnace.

Cooling surface of tops exposed to incoming air, 7½ times burning surface exposed to fire.

Tops may be redistributed, resulting in longer life.

Non-sifting tops on upper courses to retain fine coal until coked.

Only one hand adjustment for both grate movements, opening and closing.

Draft area through grates, variable, according to the rate of combustion, not constant as in hand-fired furnaces requiring variable stack draft for varying rates.

Semi-balanced dumping grate—reduces labor, and automatically breaks up clinker formation.

Reverberatory arch for coking green fuel.

Preheating of air by passing over arch, also cooling arch.

Fuel bed visible and accessible at all times.

Minimum draft required due to direct and low resistance passages through grates.

Number of stokers driven from one engine.

Adaptable to any type of boiler.

Capable of burning any commercial fuel, especially low grade.

Minimum labor required due to accessibility of fire bed.

One fireman can handle from 2000 to 8000 horse power in boilers.

Well adapted to double-fired furnace arrangements.

WESTINGHOUSE AIR COMPRESSORS, STEAM, MOTOR AND BELT-DRIVEN.

During the past nine years over 18,000 Westinghouse air compressors have been sold in the United States alone for purposes other than in connection with air-brake apparatus. That these sturdy little compressors have found a wide range of usefulness throughout the general industrial field is clearly indicated by the increasing sales of this class. This is undoubtedly due to their simplicity, neatness and compactness, and their design to occupy the smallest possible space but of ample wearing parts to insure great durability and consequent low cost of maintenance. All parts are easily accessible, and the compressors can be easily fastened to any side wall, column or other substantial support, thus requiring no floor space or foundation.

The fact that they are the recognized standard air compressors in universal use in connection with both steam and electric railroad air-brake systems throughout the world, is a sufficient guarantee of their absolute reliability. Special Publication 9012 illustrates and describes the variety of sizes in which these compressors are made.

A few of the many purposes to which Westinghouse compressors are particularly well adapted are the following:

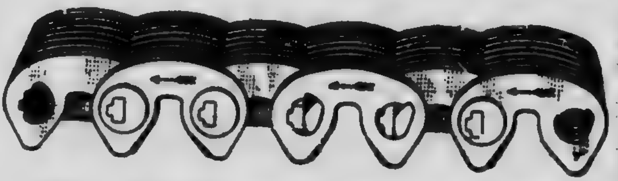
Agitating liquids and solutions in processes; air brakes on hoisting engines; air hoists of all kinds; air signal systems in mines, and whistles in shops and factories; ash disposal outfits; automobile garages; artesian well testing and cleaning; automatic sprinkler systems; blasts for furnaces; boiler-tube cleaners; bottle machinery; conveying, racking and beer bottling machinery; dusting and cleaning machinery; cleaning sheep and cattle; conveying acids, liquors and liquids; cranes; crematory furnaces; compressed air for physicians, dentists, laboratories, barbers, clippers, etc.; drying residues from filtration; elevators and elevator doors and gates; high-pressure gas transmission; grouting machines; heating systems; interlocking switch and signal systems; monotype machines; moulding machines in foundries; oil burners; oil well boring machines; painting and spraying; compressing oxygen and acetylene for oxy-acetylene blow pipe; pneumatic tools; pneumatic tubes; portable air compressing plants—steam, motor and gasoline-engine driven; rock drills; pumping wells; sand-blast outfits; sausage machines; sewage ejection; sprinkling fruits and vegetables; steering gear of steamboats; raising open-hearth furnace doors in steel mills; and vacuum cleaning plants.

MORSE SILENT-RUNNING HIGH SPEED CHAINS.

The Morse Silent-Running Power Chain is essentially a steel belt made of flat links so shaped as to form teeth on one side of the chain, which engage with teeth cut in the sprocket wheel on which it runs.

It is used in place of belting or gears to transmit power for any purpose and is made in sizes varying from ¼ HP at 8,000 R. P. M. to 3000 HP at 100 R. P. M., an aggregate of over 300,000 HP being now in successful daily operation.

By its use power may be transmitted with a positive speed ratio on short centers, practically noiselessly and with an efficiency of nearly 99%.



Morse Silent-Running High Speed Chain, Type 23.

This high efficiency is due to the use of the Morse Frictionless Rocker Joint, which consists of two pins of hardened tool steel, each forming half of the joint and so shaped and held that, as the chain bends, the rounded edge of one pin rocks upon the flat side of the other, thus substituting a rolling motion for the rubbing friction found in all other chain-joints. When the chain is straight the flat seat pin bears against one of the flat faces of the rocker pin, so that it is only when the chain bends that the load comes upon the rounded edge of the rocker. This prevents undue vibration in the strands of the chain between the sprockets.

The chain should be lubricated with a heavy paste grease containing no solid matter. For this purpose we recommend Transmission Grease No. 1 or No. 2 and Arctic Cup Grease No. 2, sold by the Standard Oil Company, the K/O Special, sold by the New York & New Jersey Lubricant Company, New York City, or the Keystone Grease No. 4 or No. 5, sold by the Keystone Lubricating Company of Philadelphia, Pa.

The chains are made in a variety of widths to suit the power transmitted and in nine pitches, the number of revolutions of the smallest sprocket determining the pitch to be used, as shown by the following table:

MORSE CHAIN AND SPROCKET DATA.

PITCH.		½	⅝	¾	$\frac{9}{10}$	$1\frac{2}{10}$	1½	2	3
Min. No. of Teeth	Small Sprocket Driver......	13	13	18	15	15	17	17	17
	Small Sprocket Driven......	17	17	21	25	29	29	31	35
Desirable number of teeth in small sprockets.......		15-17	17-21	17-21	17-23	17-23	17-27	17-31	19-31
Maximum number of teeth in large sprockets. (See Note 3.).......		99	109	115	125	129	129	129	151
Desirable number of teeth in large sprockets.......		55-75	55-75	55-85	55-95	55-105	55-115	55-115	55-155
To find pitch diameter of wheel multiply No. of Teeth by.......		.159	.199	.239	.2865	.382	.477	.636	.955
Addendum for outside diameter of sprockets 20 to 130 T. (See Note 1.)		.10	.12	.15	.18	.24	.30	.40	.60
Maximum R. P. M.......		2400	1800	1200	1100	800	600	400	250
Tension per inch width chain	Small Sprocket Driver......	80	100	120	150	200	270	450	750
	Small Sprocket Driven......	65	80	95	120	160	210	350	600

MORSE CHAIN AND SPROCKET DATA.—Continued.

PITCH.	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{15}{16}$	$1\frac{3}{16}$	$1\frac{1}{2}$	2	3
Radial clearance beyond tooth required for chain..........	.50	.62	.75	.90	1.2	1.5	2.0	3.0
Approximate weight of chain per inch wide, 1 foot long......	1.00	1.20	1.50	1.80	2.50	3.00	4.00	6.00
C Constants for Steel Pinions..............	.0045	.0063	.009	.018	.028	.035	.058	.145
C Constants for Cast Iron Sprockets..........	.16	.25	.35	.45	.7	1.	2.	4.

APPROXIMATE WEIGHT FOR STEEL PINIONS AND CAST IRON SPROCKETS.

When T = No. of teeth.
F = Face in inches.
C = Constant in pounds per inch in face per tooth. T x F x C = Weight, C.I.

Add 25% if split; add 50% if spring sprocket and split.

For Steel Pinions: $C \times T^2 (F+1) =$ Weight.

MORSE CHAIN AND SPROCKET DATA

Continued.

Note 1. Number of teeth=T.
Exact Outside Dia.=D.
For T—less than 20 teeth, D=
Pitch Dia.
For T—more than 20 teeth, D=
Pitch Dia.+2xAddendum.

Note 2. Use sprockets having an odd numbe of teeth whenever possible.

Note 3. When specially authorized, a large number of teeth than shown ma be cut in large sprocket.

Note 4. Thickness of sprocket rim, includin teeth, should be at least 1.2 time the chain pitch.

Note 5. The number of grooves in th sprocket, their width and distanc apart, varies according to pitc and width of chain. In every cas leave the designing and turning o these grooves to the Morse Chai Company.

Note 6. The width of the sprocket should b ⅛ to ¼ inch greater on smal drives, and ¼ to ½ inch greate on large drives than nomina width of the chain.

Note 7. The chain should have an even number of links and the wheels an od number of teeth.

Note 8. Horizontal drives preferred; tigh chain on top necessary for shor drives without center adjustment and desirable for long drives with or without center adjustment.

Note 9. Adjustable wheel centers desirable for horizontal drives and necessary for vertical drives.

Note 10. Avoid vertical drives.

Note 11. Allow a side clearance for chain (Parallel to axis of sprockets and measured from nominal width of chain) equal to the pitch.

Note 12. Maximum linear velocity for commercial service 1200 to 1600 feet per minute.

This data for use in preliminary design; the engineering features should always be submitted to the Morse Chain Company for approval before ordering.

DATA

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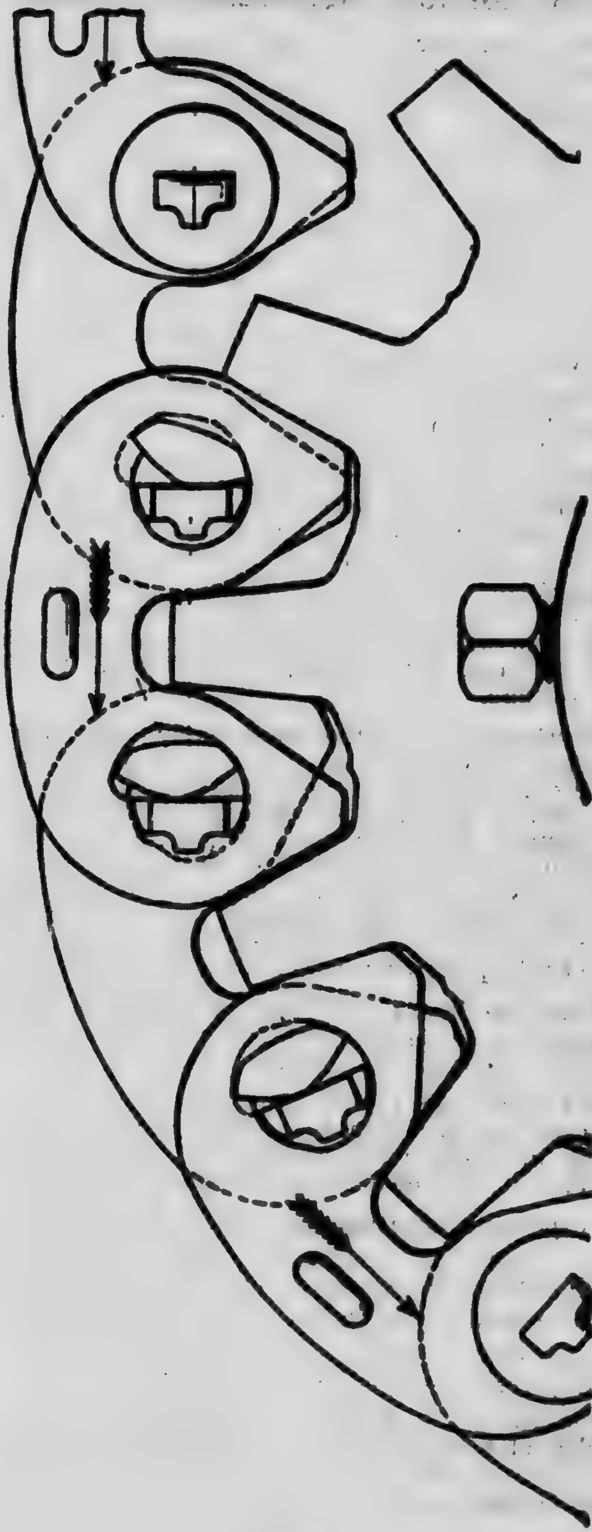


Morse Chain, Type 25, Showing Joint Action.

WESTINGHOUSE INCANDESCENT LAMPS.

Heretofore carbon filament lamps have been rated in candle power at three different watts per candle efficiencies, which was illogical and confusing, and which, many times, resulted in the improper use of the lamps. During the past year the method of rating lamps has been changed to a total watts basis; that is, lamps are now known by their watts capacity, and are marked with three voltages, known as top, middle, and bottom voltages.

Where the 3.1 w.p.c. lamp was used, lamps whose top voltage is the same as that of the line voltage should be used.

Where the 3.5 w.p.c. lamp was used, lamps whose middle voltage is the same as that of the line voltage should be used.

Where the 4.0 w.p.c. lamp was used, except for burning five in series on street railway circuits, lamps whose bottom voltage is the same as that of the line voltage should be used.

Metallized filament, tantalum, and tungsten lamps are similarly rated and labeled, and the same general rules hold for the relation of the label voltage, top, middle and bottom, to the line voltage.

Westinghouse incandescent lamps are made standard in watt capacities from 5 to 500 and for use in multiple circuits ranging from 10 to 275 volts. For use on circuits of higher voltage, lamps of lower voltage and of the same amperage can be connected in series and burned with satisfaction, provided the sum of the lamp voltages equals the voltages of the circuit. When burned in this manner, each lamp gives the candle power for which it was designed.

Miniature lamps are made with various bulb designs for table and other decorations. They are also used in small signs.

The watts per candle efficiency of carbon-filament lamps vary with the voltage, while the life varies inversely with voltage. Within a limit of five volts the changes are as follows:

1 percent variation in voltage causes approximately,

6 percent direct variation in candle power.

2 percent direct variation in total watts consumed, and

18 percent inverse variation in life.

The life of a lamp is considered to be the number of hours it burns until the lamp becomes useless from breakage, open circuiting, or any other cause.

Equivalent ratings of carbon-filament lamps on the new and on the old method of rating.

100 to 130 Volts.

New Rating			Old Rating	
Label	Rating Total Watts	Label Voltage	C. P.	W. P. C.
Single Voltage Label	10	Single	2	5.
	20	"	4	4.8
Three Voltage Label	25	Top	8	3.1
	25	Middle	6	3.7
	25	Bottom	4	4.8
	30	Top	10	3.1
	30	Middle	8	3.6
	30	Bottom	6	4.3
	50	Top	16	3.1
	50	Middle	12½	3.6
	50	Bottom	10	4.2
	60	Top	20	3.0
	60	Middle	16	3.5
	60	Bottom	12½	4.1
	100	Top	32	3.1
	100	Middle	25	3.6
	100	Bottom	20	4.2
	120	Top	40	3.1
	120	Middle	32	3.6
	120	Bottom	25	4.2

200 to 275 Volts.

Single Voltage Label	35	Single	8	4.4
	60	"	16	3.8
	120	"	32	3.8

The 200-275-volt 35-watt lamp marked dow 11 volts will correspond to the old 5-c.p., 20 260-volt sign lamps.

The manufacture of lamps for operating fiv in series on street railway circuits will be continued as heretofore, excepting that these lamp will be known by their watts capacity.

The following table shows the life of 50 wat carbon-filament lamps at different efficiencie at normal voltage, and at an increase abov normal:

Actual Total Watts	Label Voltage	Effi-ciency	Life at percentages of normal voltage		
			100%	101%	103%
			Hours	Hours	Hours
50.0 W.	Top V.	2.97	700	575	375
48.2 W.	Middle V.	3.18	1000	825	550
46.4 W.	Bottom V.	3.39	1500	1225	800

It will be seen that the lamp consumes approximately 50 watts at top voltage, 48.2 watts at middle voltage, which is two volts below top voltage, and 46.4 watts at bottom voltage, which is two volts below the middle and four volts below the top. Hence, if a lamp is operated on a line voltage corresponding to top, middle, or bottom voltage or at a voltage above this, the average result is that given in the table.

It will also be seen that a 50-watt carbon-filament lamp will give an average of 700 hours' life at top voltage and 1500 hours' life at bottom voltage, which is but four volts below the top. Therefore, the selection of the lamp voltage to meet the variation in line voltage is important if the life of the lamp is not to be greatly reduced.

METALLIZED-FILAMENT LAMPS.

These lamps are very similar to the carbon-filament lamps, excepting that, in addition to the ordinary carbon-filament processes, the filaments pass through two "metallizing" processes, which radically change the characteristics of the filament.

Instead of having a negative temperature co-efficient like ordinary carbon, the metallized filament has a positive temperature co-efficient like that of metals, its resistance increasing with increasing temperature. By the metallizing processes the efficiency is increased from

3.1 to 2.5 watts per candle with the same useful life, and the effect of varying voltage is decreased.

The metallized-filament lamp is rated in total watts at a given "watts-per-candle," and like the carbon-filament lamps at three voltages, top, middle, and bottom voltage, in steps of two volts each. The life of the lamp varies inversely as the voltages.

METALLIZED-FILAMENT LAMPS.

40, 50 and 80 Watts.

100 to 130 Volts	Rating Total Watts	Actual Total Watts	Watts per Candle	M. H. C. P.	M. S. C. P.	Useful Life
Top Voltage	40	40.	2.56	15.6	12.9	600
	50	50.	2.50	20.0	16.5	700
	80	80.	2.46	32.5	26.8	700
Middle Voltage	40	38.8	2.71	14.2	11.7	900
	50	48.5	2.65	18.3	15.1	1000
	80	77.6	2.60	29.8	24.6	1000
Bottom Voltage	40	37.8	2.89	12.9	10.6	1300
	50	47.3	2.81	16.6	13.7	1500
	80	75.6	2.78	26.8	22.1	1500

TUNGSTEN LAMPS.

1st. **Current Consumption.** The current required for producing equal candle power with tungsten lamps is approximately one-third of that required by carbon lamps, and approximately one-half of that required by metallized-filament lamps.

2nd. **The Quality of Light.** The light given by tungsten lamps is nearer day light than any other artificial illuminant.

3rd. The maintenance of candle power of tungsten lamps is superior to that of other lamps.

4th. Tungsten has a positive temperature co-efficient, i. e., the resistance increases rapidly as the temperature increases. Therefore an excessive voltage that would break or permanently injure a carbon-filament lamp has relatively little effect upon tungsten lamps.

5th. The change in candle power resulting from a change in voltage of the circuit is only about three-fifths as great as that of the carbon or metallized-filament lamp. The change in life is, however, approximately the same.

6th. The length of life of the tungsten filament is greater than that of the carbon or metallized filament. The tungsten filament, being pure metal, does not deteriorate and change in character as do the other filaments.

7th. As tungsten lamps are made in units of all capacities from 25 to 500 watts, a given amount of illumination can be secured with fewer units with resulting economy in installation.

8th. The most radical improvement of the past year has been the development of the "Wire Type" lamp with its one piece of tungsten wire without joints from leading-in wire to leading-in wire and the joints with the leading-in wires protected by the resiliency of a coiled spring. The electrical contact is insured by melting the metal of the leading-in wire around the free end of the tungsten filament.

WESTINGHOUSE "WIRE TYPE" TUNGSTEN LAMPS.

Fitted with Edison Base and Labeled with the Three-Voltage Label.

200 to 250 Volts.

Rating Total Watts	Label Voltage	W. P. C.	C. P.	Hours Life	Standard Package
500	Single	1.25	435	1000	8
150	Single	1.25	125	1000	24
100	Single	1.25	80	1000	24
60	Single	1.25	48	1000	50
45	Single	1.33	34	1000	50

100 to 125 Volts.

Rating Total Watts	Label Voltage	W. P. C.	C. P.	Hours Life	Standard Package
500	Three	1.15	435	1000	8
400	Three	1.15	348	1000	8
250	Three	1.15	217	1000	12
150	Three	1.20	125	1000	24
100	Three	1.20	83	1000	24
60	Three	1.20	50	1000	50
40	Three	1.25	32	1000	50
40S.B.	Three	1.25	32	1000	100
25	Three	1.33	19	1000	100

57 to 65 Volts.

50	Single	1.20	42	1000	100
40	Single	1.20	33	1000	100
25	Single	1.25	20	1000	100
20	Single	1.25	16	1000	100
15	Single	1.38	11	1000	100

25 to 34 Volts.

50	Single	1.20	42	1000	100
40	Single	1.20	33	1000	100
25	Single	1.20	21	1000	100
20	Single	1.20	17	1000	100
15	Single	1.25	12	1000	100
10	Single	1.25	8	1000	100

COMPARISON OF LIGHT GIVEN FOR SAME COST PER 1000 HOURS—100-WATT TUNGSTEN AND 100-WATT CARBON LAMPS; AND SAVING FOR EQUAL LIGHT.

	Tungsten 1-100 watt 1.20 w. p. c	Carbon 1-100 watt 2.97 w. p. c	Carbon 2.48-100 watt 2.97 w. p. c.
Candle Power	83.3	33.6	83.3
Average cost of lamps	1.04	.24	.595
Average life of lamps	1000	600	600
Renewal cost per 1000 hours	1.04	.40	.9917
Power consumed per 100 hours k. w. h.	100.	100.	248.
Cost of Power at 5 cts.	5.00	5.00	12.40
Cost of Power at 10 cts.	10.00	10.00	24.80
Cost of renewals and power at 5 cts.	6.04	5.40	13.39
Cost of renewals and power at 10 cts	11.04	10.40	25.79
Comparison of light for same cost	100%	42.8%	42.8
% saving for equal light 5 cts.	55	....	0.0
% saving for equal light 10 cts.	57	....	0.0

This makes an average saving of 56 percent in the cost for lamp renewals and power in addition to which there is a saving effected in the cost for wiring by the reduction of the number of outlets, the quantity of material, and the reduction of the load.

CALCULATING GENERAL ILLUMINATIO

In estimating the illumination required fo room, A times C equals total candlepower, wl A equals area of floor space in square feet, C is a constant found in the accompanying ta opposite the class of service considered, the c stant depending on the color of the walls each case. To secure a uniform distribution this light, judgment must be exercised, howev in selecting the size of units and their locati

Class of Service.	Foot-Candles	Const. C, Wa Dark	Lig
Reading	2.0	0.50	0.4
Theaters.	2.0	0.50	0.4
Churches.	3.5	0.80	0.7
General Store.	3.5	0.80	0.7
Desk illumination. . .	3.5	0.90	0.7
Bookkeeping.	4.0	0.95	0.8
Clothing.	5.5	1.30	1.1
Drafting and engraving.	7.0	1.70	1.4
Window lighting. . . .	10.0	2.50	. . .

This table is to be used only where the ligh units are equipped with good reflectors.

Example.—A room 70 feet by 120 feet, wit light walls, is to be lighted to give good readin illumination. Referring to table, two foot candles are required. Constant for light walls 0.40; area, 70 feet by 120 feet, 8,400 square feet. 8,400 times 0.40 equals 3,600 candles. If twelve units (three rows of four each) have been decided upon, 3,360 divided by 12 equals 280 candles per unit or cluster.

Or, if a unit containing five sixty-watt (48-c.p.) tungsten lamps had been decided upon, 5 times 48 equals 240 candles. Then dividing 3,360 by 240, 14 units.

Total candlepower multiplied by efficiency of lamps (watts per candlepower) gives total watts consumed. If tungsten lamps are used, multiply by 1.25; metallized-filament, 2.5; carbon, 3.5, etc.

The following table compares energy used and energy saved by using different classes of lamps to produce same candlepower.

Lamp.	% Energy Used.	% Energy Saved.
3.39 w.p.c. Carbon	283	0.0
3.18 " "	266	6.1
2.97 " "	248	12.8
2.50 Metallized	208	26.2
1.97 Tantalum	164	41.8
1.20 Tungsten	100	64.6

P. T. & T. R. R. SIGNALING & INTERLOCKING FOR NEW YORK CITY TERMINAL AND APPROACHES.

Character of System.

The system adopted is the well-known electro-pneumatic type already extensively used on the Pennsylvania Railroad and manufactured by the Union Switch & Signal Company, with certain modifications and improvements prompted by recent developments in general signal practice and by the requirements of electric traction in the track circuit control of signals, lever locks, etc.

Improvements.

These improvements embrace a higher degree of perfection in the insulation of the various parts of the system from each other and from their surrounding; a wider margin of separation in machine contacts; and a greater degree of security in methods of mounting and securing controlling contacts and like parts.

They comprise means for obtaining positive control of all signals of interlocking plants by actual position of switches over which they govern; the automatic control of signals by track conditions in advance of them and by position of the next succeeding signal to which the impending train movement leads; the automatic locking of all switches in every route by the entrance of trains upon these routes and the automatic release of switches in the rear of trains immediately the rear of a train passes clear of the fouling point of the track including the switch.

They, further, involve means for giving visual indications to the operator of every act of a train in physically locking and releasing the levers controlling switch and signal operation; means for permitting the joint use of all tracks for traffic in either direction between adjacent towers by co-action of towermen and track conditions; the automatic announcement of trains in their approach to the terminal station through the various tunnels and the delineation of their movements from block to block through the tunnels by means of indicators in each tower adjacent to tunnel portals.

Perhaps the greatest departure from ordinary practice that has been made in this installation results from the embodiment therein of the Rudd & Rhea system of upper quadrant 3-posithe signaling now a recognized feature of standard practice on the Pennsylvania Railroad. Briefly put, the use of 3-position signals combines the functions formerly expressed by two signals having but two positions each, and the movement of the signal arm from horizontal to vertical through the upper quadrant instead of through the lower quadrant, as has been the general custom of the past, finds general favor to-day because of the tendency of sleet and ice accumulations upon the arm to increase the effect of gravity to restore the signal to the stop position instead of to counteract or lessen that effect, as in the case of lower quadrant operation.

Because of what may be regarded as perpetual night conditions within the tunnels and in the larger portion of the terminal track area, the use of signals having arms or blades for defining their positions became of very secondary importance, and this fact coupled with the usual close quarters encountered in such places prompted the total elimination of the arms from all block signals of the tunnels and from all but the ground or dwarf signals of the terminal area.

The substituted form of signal, therefore, had need for no other mechanism than that required for changing the colors of a system of stationary lights in such a manner as to reproduce the same colors and combinations as these produced by changes in position of the semaphore type of signal under like changes in the controlling currents. These signals are, therefore, simply receptacles carrying colored lenses behind which are located standard 4 c.p. incandescent lamps (2 in multiple for each lens) and the "mechanism" consists of simple relays (housed in separate shelters near the signal), the contacts of which were adapted to shift the current from lamps to lamps, and thus to change the colors displayed as the relays are energized or de-energized by manipulation of the machine levers or by the action of trains upon track circuits or by both as in many cases called for. As before implied, some of the signals of the terminal interlockings are located out in the open where full daylight conditions prevail.

Because of the difficulty of obtaining ample clearances and suitable supports for semaphore signals at these places and in order to also maintain a uniform type of signal within the terminal area special lenses and lamps of higher candle power are employed in the "lamp" type of signal in these exposed places which even in the most exposed places give a clear light indication throughout the somewhat limited range of observance there encountered.

Elsewhere, outside of the terminal and tunnels, this form of signal would not prove satisfactory because of the higher speeds and longer ranges of observation involved, and this fact—coupled with the abundance of room there for standard signal construction—prompted the use of the semaphore type for the automatic signals across the Meadows and for the Sunnyside, Harrison and Hackensack Draw Interlockings.

The rails of the tracks throughout the system are naturally included in the return circuit of the propulsion system, and this fact compelled the use of track circuits that would be immune from faulty operation due to the influence of the power current within these rails.

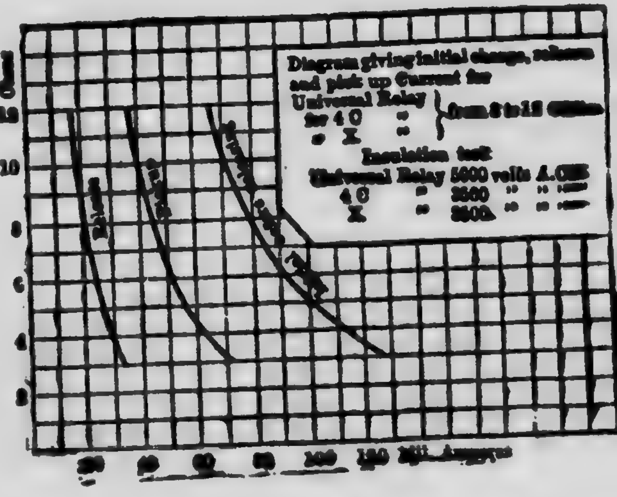
Because of the impracticability of obtaining close definition between the limits of the great number of short track sections that are required within the tracks of the various interlockings by surrendering all of the rails of all of the tracks of the system to the return power system, and because the vast capacity of these rails within the interlocked territory permits an entirely ample return capacity when half of the total rail conductively is eliminated, but one rail of each track throughout the various interlockings is included within the power return system—the other rail being excluded for subdivision, by rail insulations, into the "live" rails of the track circuits and energized each by a lead from transformers located at a convenient proximity, the other terminals of these transformers being connected with the rails that constitute the common return for both the propulsion current and that of the various track circuits.

At the opposite end of each track circuit so formed, the terminals of a special A. C. relay are connected so that, while responding to the current that reaches it from the transformer through the rails when the track is unoccupied it can only be deprived of operating energy by either the presence of a train upon the two rails supplying its energy or by an abnormal flow of direct current through it from the power circuits in the event of derangement occurring which would cause such a flow.

These one-rail track circuits are adapted, through various intermediate circuits and instruments, to the automatic control of signals and lever locks by trains within the interlocking. Outside of the interlocked territory a somewhat different situation is presented. Here the full capacity of all rails is of value to the economy of the propulsion system and means are, therefore, introduced within the rail circuits for controlling the automatic block system by which this full capacity is almost fully realized.

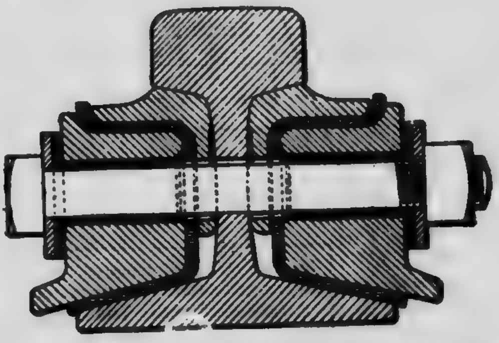
At the terminal of each track circuit (each circuit including the distance between block signals, or approximately 8000 feet) both rails of the track are insulated and the four terminals are so united through the medium of four reactance coils of extremely low ohmic resistance, yet of high carrying capacity, that the direct current of the propulsion return is not materially affected. This current traveling in opposite directions in separate windings around a common core of the bond produces no magnetizing effect upon the iron core of the bond when the volume of current through each rail is alike, as is normally the case. The alternating current of the track circuit, however, in its attempt to flow, not from end to end (through the bond) of adjacent rails as does the propulsion current, but from the end of one rail through the bond to the end of the rail paralleling it and forming the other leg of the track circuit, passes around the iron core through windings that unite to magnetize the iron core. Because of this fact and the low resistance of the magnetic circuit of the core a high degree of reactance is developed which so retards the current flow as to permit the maintenance of a moderate difference of A. C. e.m.f between the ends of the parallel rails.

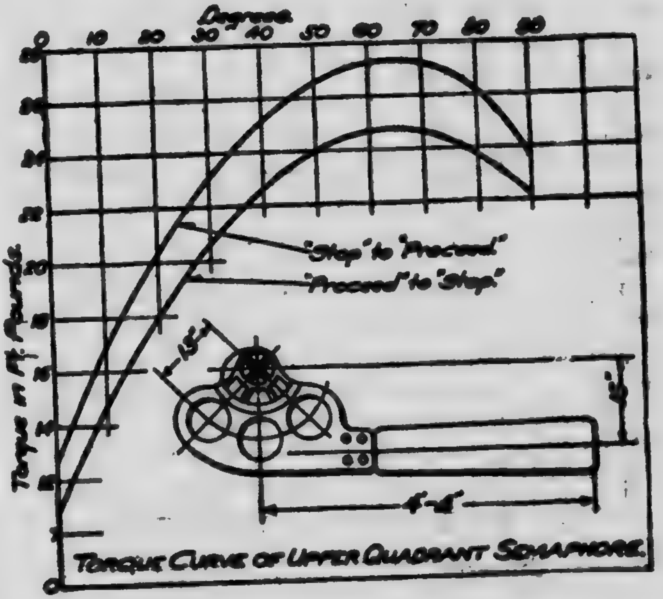
Each track circuit has thus at each end means for sustaining an A. C. potential difference between its two rails by means immune t influence by direct current.



THE KEYSTONE INSULATED RAIL-JOINT.

The special feature of this joint is the metal filler under the rail head, which increases the area of insulating material. Thus diminishing the pressure per unit of area of insulation, makes it possible to set the bolts tighter, insuring, with the arrangement and sectioning of the rolled-steel filler and angle bars, a more rigid and permanent joint, secure against vertical or horizontal play. The breaking of rails through bolt-holes at insulated joints often occurs where vertical relative movement between the rails is permitted. The Keystone construction avoids this and all other movement which tends to abrade or wear the insulation, presenting a firm, tight, mechanically-continuous joint of high electrical insulation.

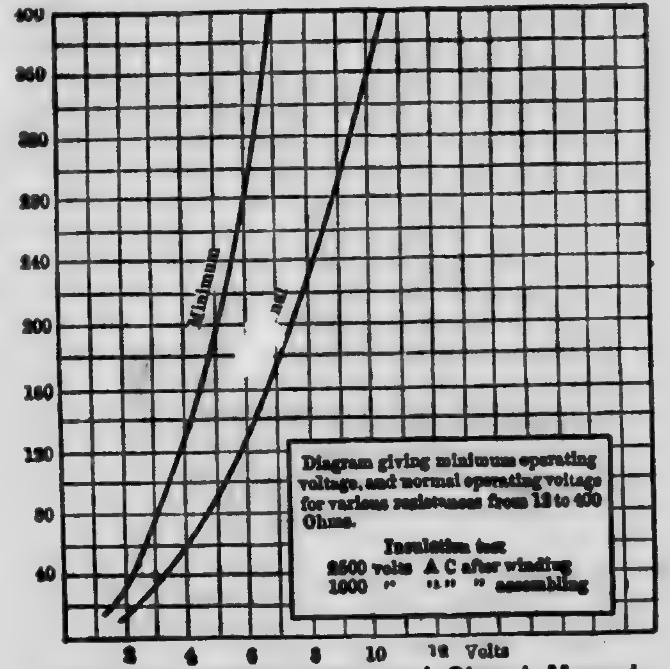




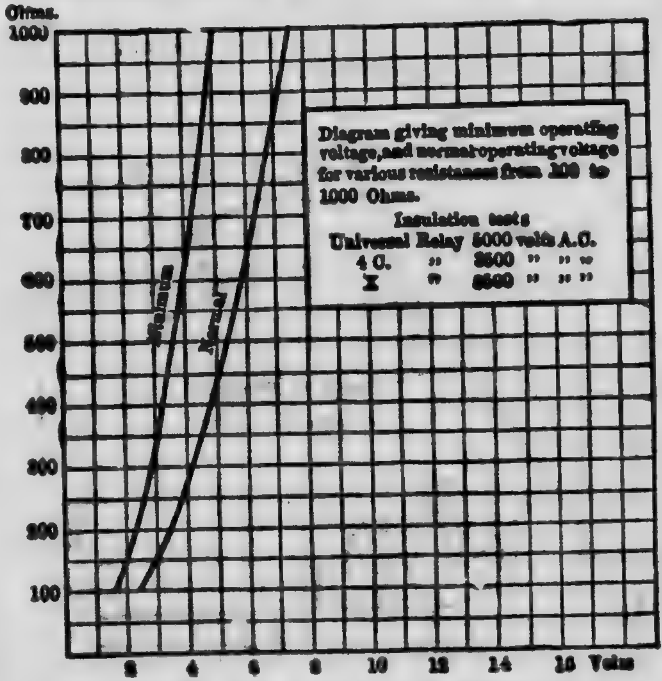
TORQUE CURVE OF UPPER QUADRANT SEMAPHORE.

THE UNION SWITCH AND SIGNAL CO.

Curves for Electric Signal Appliances.



Pneumatic Switch Valve and Signal Magnet.



Universal, 4 C and X Relays.

WESTINGHOUSE NERNST LAMPS.

The new Westinghouse Nernst lamps in both single-glower and multiple-glower types are characterized by marked mechanical improvements, making them simpler, more durable, and easier and cheaper to maintain, while their natural downward diffusion of light avoids the necessity of reflecting glassware. The glowers are improved in both mechanical construction and in composition, greatly increasing their efficiency. Fig. 1 shows 114.8 to be the mean lower hemispherical candle-power of a 132-watt lamp equipped with clear glassware, representing an efficiency of 1.2 watts per candle-power, or a gain in efficiency of 41½% over the old form of lamp. Fig. 2 gives the light distribution from a four-glower 230-volt lamp consuming 552 watts, equipped with dome shade and heater case. Its mean lower hemispherical candle-power is 516, giving an efficiency of 1.07 watts per candle-power. It will be noted that this unit is the largest incandescent unit on the market and also delivers the most light for the energy consumed. Its distribution is ideal, especially for large interiors with high ceilings.

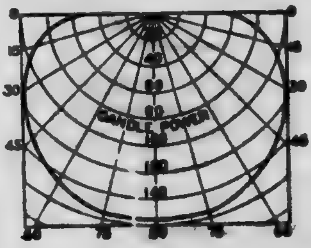


Fig. 1.

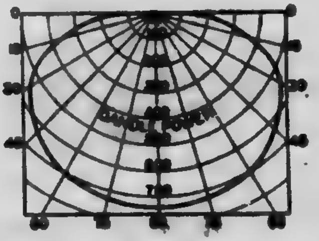


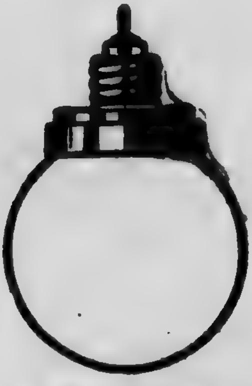
Fig. 2.

Light Distribution Curves of Single-Glower and Multiple-Glower Westinghouse Nernst Lamps.

The value of a lighting system does not depend upon its efficiency alone. All other factors being equal, a system having a lower efficiency may have its increased current cost more than offset by its lower cost of maintenance. The Westinghouse Nernst system is unique, however, in combining the highest efficiency with the lowest maintenance cost. This low maintenance cost is accomplished through the simpler and more rugged construction, without the aid of reflecting glassware and by its simple and inexpensive system of renewal. The renewal of the single glower units, viz.: 66, 88, 110 and 132 watts A.C. and D.C., 110 and 220 volts, is a screw burner containing the glower and heater. This can be replaced by anyone. This feature makes it suitable for domestic as well as commercial use.

The multiple-glower units are provided with the new type wafer heater holders which makes their renewal also extremely simple and inexpensive. This holder consists of a single wafer heater which can be renewed by simply slipping into place, without in any manner interfering with the glower.

Multiple Glower Westinghouse Nernst Lamp.


Screw Burner for Single Glower Westinghouse Nernst Lamp.

Westinghouse Nernst Chandeliers.

Westinghouse Nernst Chandelier. Art Nouveau Design.

Westinghouse Nernst Chande
liers are constructed with th
mechanism of the lamp conceale
within the ornamental stem, lea
ing only the small screw-bas
burners at the end of the arm
The Nernst burner, ranging fro
110 to 132 watts, occupies le
space than an ordinary 16-c.
carbon-filament lamp. The si
light 660-watt chandelier giv
the greatest amount of illumin
tion for a single outlet, of a
incandescent fixture within t
wattage limit fixed by the Unde
writers.

Westinghouse Nernst Chan
liers are made in three artis
designs: Renaissance, Art No
veau and Composite.

COOPER HEWITT LAMPS

Direct and Alternating Current

The Cooper Hewitt lamp is a distinct type of electric lighting unit, differing from others in principle, construction, and quality of rays emitted. Its principle is distinctive in that it depends for its luminosity on an incandescent vapor. In construction it differs from other types in having an exhausted glass tube, one inch in diameter and from 21 to 50 inches long, which becomes the visible luminous surface; on account of the great area of this surface the intrinsic brillancy (glare) of the lamp is much lower than that of any other commercial light-source. The quality of the light is different, as it is of a bluish-green tone and no red rays are emitted. Of course, the lamp is not suitable for use where color values must be maintained.

The peculiar qualities of its rays give to the Cooper Hewitt lamp two very important advantages: First, it enables the eye to distinguish fine detail to a remarkable degree; in other words, it increases acuity of vision to an extent estimated as equal to a magnification of at least two diameters; second, the absence of red rays reduces eye-strain and fatigue very materially. The Cooper Hewitt lamp is, therefore, especially suitable for the illumination of machine shops, textile mills, printing offices, draughting rooms, and all other places where close eye-work must be done. The light has another advantage in that it renders objects more easily seen in shadow; for this reason it is used very sucessfully in large erecting works, heavy machine shops, and wherever work must be done by general illumination.

The Cooper Hewitt lamp is the most efficient of the various forms of electric lamps. Furthermore, its cost of maintenance is only about half that of any other source.

Cooper Hewitt	efficiency	.5	watts	per	candle.
Tungsten.....	“	1.25	“	“	“
Enclosed-arc...	“	2.0	“	“	“
Incandescent...	“	3.5	“	“	“

Cooper Hewitt Lamp Units—Direct Current.

Type.	Average Watts.	Length of tubes (inches).	Average Candle Power.	Watts per candle.
H........	192	21"	300	.64
Double H.	385	2-21" ea.	600	.64
K.......	385	43"	700	.55
P.......	385	50"	800	.48

Alternating Current.

F........	400	50"	800	.50

Power Factor, 51% for lines of 40, 50 or 60 cycles and voltages between 100 and 500.

The Lamp Tube is a sealed glass vessel exhausted to a high degree of vacuum, and is useful as long as the vacuum remains unimpaired. The only cost of maintenance in lighting by Cooper Hewitt Lamps is for tube renewals. As the life of the tubes averages several thousand hours, the maintenance cost is very low.

AVERAGE HOURS LIFE OF TUBES IN THE FIVE CIRCUITS.

The following figures are taken from an installation of forty (Type H) lamps designed to be operated either two in series on 110 volts, four in series on 220 volts, or 8 in series on 550 volts. This installation in a power station of a large traction company, operates lamps in series on 500 volts direct current taking 3⅓ amperes for each circuit. The lamps burn practically 24 hours per day.

TUBES.	No. 1	No. 2	No. 3	No. 4	No. 5
Total renewal	14	18	14	16	17
Av. hrs. of original	11269	10822	8666	11832	11198
Av. hrs. of present.........	9232	8279	11479	7108	9860
Av. hrs. of burned out..	6469	7808	5719	7515	6483
Av. hrs. of all..	7491	7987	7845	7379	7484

SUMMARY.

Av. of 40 Original Tubes..	10657	hours.
Minimum	664	"
Maximum	23721	"

Of the original tubes the following are still in use:

Two used	23721	hours.
One "	22033	"
Two "	20601	"
Three "	18414	"

Maintenance. Cost of renewals, 1-20 of 1c per lamp per hour.

Installation. 8.75 K. W.

Candle Power. Total, 12,000 candles.

COMPARATIVE COST.

	Two Cooper Hewitts.	Four Enclosed Arcs.	One Flaming Arc.
First Cost, Bare Lamp	$36.00	$60.00	$60.00
Total Current	.77 K W	2.2 K W	.55 K W
Hours used per year	3600	3600	3600
Curent per year	2772 K W	7920 K W	1980 K W
Maintenance per K W hour	$.0045	$ .005	$ .03
Maintenance per year	$12.47	$39.60	$59.40
Cost Current at 1c K W	27.72	79.20	19.80
Depreciation — 10%	3.60	6.00	6.00
Total Cost of Maint., Current Consumpt. and Dep., per year	$43.79	124.80	85.20

SOME TYPICAL INSTALLATIONS OF COOPER HEWITT LAMPS.

Miscellaneous.

American-LaFrance Fire Engine Co., Elmira, N. Y.	298	H
American Sheet & Tin Plate Co. (several plants)..........24 K, 212 H	104	HH
Boston El'v'd Co., Boston, Mass.	250	H
Cutler-Hammer Mfg. Co., Milw'k.,Wis.	194	K
Gov. Ptg. Office, Wash'gt'n, D. C.	1614	H
Nathan Mfg. Co., New York	186	H
Otis Elevator Co. (3 Plants)	271	K
Stehli & Co. (3 Plants)	481	P
S. Slater & Sons, Webster, Mass.	452	H

Automobile Factories.

American Motor Co., Indianapolis, Ind.	86	H
Excelsior Supply Co., Chicago, Ill.	110	H
The Garford Co., Elyria, O.	200	H
Mitchell Motor Car Co., Racine, Wis.	181	H
Geo. N. Pierce Co., Buffalo, N. Y.	250	H

Cotton Mills.

Brighton Mills, Passaic, N. J....82 P	54	H
Ipswich Mills, Ipswich, Mass.	100	[illegible]
Pacific Mills, Lawrence, Mass.	180	H
Taylorsville Cotton Mills, Taylorsville, N. C.	26	H

Drafting Rooms.

Armour Institute, Chicsago, Ill....1 K	8	H
Cambria Steel Co., Johnstown, Pa.	82	H
Link Belt Mach. Co., Chicago, Ill.	24	H
National Tube Co., McKeesport, Pa.	20	H
Standard Steel Car Co., Butler, Pa.	50	H

Foundries.

Bettendorf Axle Co., Bettendorf, Ia.	86	HH
Buckeye Steel Castings Co., Columbus, Ohio	120	K
The Faulk Co., Milwaukee, Wis.	50	HH
McConway-Torley Mfg. Co., Pittsburg, Pa.	66	K
Tiffin Mall. Iron & Chain Co., Tiffin, Ohio	56	K

Machine Shops.

Chicago R'way Sup. Co., Ch'go, Ill.	70	H
DeLaval Separator Co., Poughkeepsie, N. Y.	70	K
Latrobe Steel Co., Latrobe, Pa.34 HH	76	H
J. L. Mott Co., Trenton, N. J...54 K	65	H

Offices.

American Tobacco Co., New York	48	H
C., R. I. & P. R. R., St. Louis, Mo.12 K	28	H
United Cigar Stores Co., New York	34	H
Wells, Fargo & Co. Express, N. Y.	51	H

Paper Mills.

Philip Carey Mfg. Co., Cincinnati, O.	52	H
International Paper Co., Fort Edward, N. Y.	118	H
Warren Mfg. Co., Milford, N. J.	44	H

Printing Plants.

Boston Herald Co., Boston, Mass.	66	H
Con. P. Current Print Co., St. Louis, Mo.	74	H
Chicago Tribune, Chicago, Ill.	54	H
Bureau of Engr. & Ptg., Washington, D. C. 44 K	72	H
N. Y. World, N. Y. 156 T	242	H

Railroads.

C., C., C. & St. L. Rwy. Co., Beech Grove, Ind. 169 P	14	H
Illinois Central R. R., Chicago, Ill.	54	K
N. Y. C. & H. R. R., Albany, N. Y.	185	F
Wabash Railway, Pittsburg, Pa.	100	H

Silk Mills.

Kaltenbach & Stephens (Ribbon Weaving), Allentown, Pa.	398	H
Pelgram & Meyer, Boonton, N. J.	54	H
Singleton Silk Mfg. Co., Dover, N. J.	98	H

Silk Throwsters.

Crane Bros., Kingston, Pa.	42	H
J. H. & C. K. Eagle, Shamokin, Pa.	72	H
R. & H. Simon, Easton, Pa.	50	H

Traction Companies.

Indiana Union Traction Co., Anderson, Ind.	42	K
Oneida Railway Co., Syracuse, N. Y.	120	H
United Traction Co., Albany 10 K	16	H

Warehouses.

Montgomery, Ward & Co., Chicago	300	H
Sprague-Warner Co, Chicago, Ill.	102	H
U. S. Appraiser's Store, N. Y.	170	H

Wire Manufacturers.

Am. Steel & Wire Co. (5 Plants) 191 K	84	H
John A. Robling Sons Co., Trenton, N. J. 6 K	246	H

Woolen Mills.

S. Slater & Sons, Webster, Mass.	452	H
Warrenton Woolen Co., Torrington, Conn. 26 K	84	H
Gera Mills, Passaic, N. J.	32	H

STATISTICS OF CITIES IN U. S.

CITIES.	Area in Square Miles.	Estimated Population Jan. 1, 1910	Assessed Valuation of All Taxable Property.	Per Cent. of Actual Val.	Tax Rate
Albany, N. Y.	11¾	100,000	$83,438,325	90	$1.94
Atlanta, Ga.	26	150,000	101,000,000	60	1.25
Baltimore, Md.	31½	650,000	624,482,590	100	2.16
Binghampton, N. Y.	10	48,000	32,130,115	66⅔	2.35
Boston, Mass.	42⅝	629,478	1,348,041,627	100	1.65
Bridgeport, Ct.	13.4	100,000	79,211,322	100	1.58
Brooklyn Boro., N.Y.	77⅝	1,589,250	1,439,142,030	90	1.74
Buffalo, N. Y.	42	415,532	307,300,555	100	1.89
Cambridge, Mass.	6¼	100,000	106,958,135	100	2.10
Camden, N. J.	9	100,000	51,825,861	100	2.00
Charleston, S. C.	5⅛	64,000	18,960,821	50	2.88
Chattanooga, Tenn.	5	65,000	23,984,000	48	1.65
Chicago, Ill.	190⅓	2,610,681	477,190,399	33	7.66
Cincinnati, O.	43⅜	460,000	250,283,550	60	3.11
Cleveland, O.	45	550,000	256,719,375	35	3.37
Cohoes, N. Y.	8	25,000	11,545,036	100	.70
Columbus, O.	16⅛	200,000	87,307,905	66⅔	3.21
Council Bluffs, Iowa.	16¼	35,000	17,179,220	80	2.25
Covington, Ky.	6½	68,000	26,534,138	75	1.75
Dallas, Tex.	18½	100,000	62,288,730	33⅓	1.80
Davenport, Iowa.	8	50,000	23,281,855	50	3.40
Dayton, O.	16½	140,000	58,612,090	—	2.96
Denver, Col.	59¼	225,000	132,000,000	60	3.50
Des Moines, Iowa.	54⅛	100,000	20,000,000	25	3.74
Detroit, Mich.	40	450,000	359,819,910	100	1.81
Dubuque, Iowa.	11	50,000	25,633,110	80	1.30
Duluth, Minn.	67¼	90,000	37,283,400	33⅓	3.81
Elizabeth, N. J.	9⅝	70,000	52,065,175	100	1.60
Elmira, N. Y.	7½	50,000	20,215,776	80	2.56
Erie, Pa.	7 2-3	68,000	23,565,525	60	2.55
Fall River, Mass.	41	120,000	88,279,138	100	1.89
Fort Wayne, Ind.	9½	65,000	30,900,000	75	1.10
Galveston, Tex.	7¾	40,000	25,734,412	50	1.82
Grand Rapids, Mich.	17½	110,000	83,528,700	100	1.94
Harrisburg, Pa.	11	80,000	42,400,339	60	.95
Hartford, Ct.	17¼	105,000	106,574,623	75	1.80
Haverhill, Mass.	32	45,000	30,991,640	100	1.86
Hoboken, N. J.	1¼	75,000	61,807,501	100	1.72
Holyoke, Mass.	16¼	56,000	47,000,000	100	1.70
Houston, Tex.	16	100,000	60,268,660	50	1.70
Indianapolis, Ind.	31	239,500	176,665,190	66⅔	1.82
Jacksonville, Fla.	9¼	65,000	35,967,120	50	1.50
Jersey City, N. J.	19-2	251,000	235,617,539	100	1.88
Kalamazoo, Mich.	8 1-6	45,000	20,562,430	100	—
Kansas City, Mo.	62	375,000	135,580,492	50	1.27
Lawrence, Mass.	7	85,000	59,000,000	100	—
Little Rock, Ark.	10½	60,000	20,274,540	50	2.70
Los Angeles, Cal.	90	325,000	276,751,517	50	1.47
Louisville, Ky.	21	290,000	165,000,000	80	1.75
Lowell, Mass.	14	110,000	75,445,738	100	1.94
Lynn, Mass.	11⅓	85,000	70,076,492	80	2.00
Manchester, N. H.	33⅝	70,000	38,102,944	70	2.05
Memphis, Tenn.	16	200,000	85,000,000	60	1.76
Milwaukee, Wis.	22⅝	375,000	232,227,790	50	2.56
Minneapolis, Minn.	53¼	310,000	175,912,389	53	2.65
Mobile, Ala.	15	70,000	28,935,307	30	2.35
Nashville, Tenn.	17 2-5	140,000	70,645,425	80	1.50
Newark, N. J.	23	350,000	327,926,050	100	1.91
New Bedford, Mass.	19⅝	100,000	77,796,481	80	1.90

STATISTICS OF CITIES IN U. S.

(CONTINUED)

Cities.	Area in Square Miles	Estimated Population Jan. 1, 1910	Assessed Valuation of all Taxable Property.	Per Cent. of Actual Val.	Tax Rate
New Brunswick, N.J.	2	29,000	$11,515,056	66⅔	$2.20
New Haven, Ct.	22[illegible]	140,000	119,592,508	100	1.75
New Orleans, La.	192	375,000	226,581,9[illegible]2	75	2.80
Newport, R. I.	8	25,400	50,042,000	66⅔	1.30
Newton, Mass.	18	40,000	70,796,890	100	1.82
New York City	326[illegible]	4,730,350	7,250,500,559	90	
Omaha, Neb.	24[illegible]	155,000	27,571,271	20	5.73
Paterson, N. J	8[illegible]	130,000	95,243,359	100	1.71
Peoria, Ill.	8[illegible]	71,000	11,175,445	20	8.07
Philadelphia, Pa.	129[illegible]	1,545,800	1,358,675,057	100	1.50
Pittsburgh, Pa.	41	580,000	709,905,718	90	1.38
Portland, Me.	21[illegible]	62,000	58,453,415	100	2.08
Portland, Ore.	51	275,000	240,000,000	75	2.00
Poughkeepsie, N. Y.	3[illegible]	29,000	14,772,000	80	2.12
Providence, R. I.	18[illegible]	215,000	240,618,600	100	1.65
Quincy, Ill.	5-35	40,000	10,102,124	33	4.54
Reading, Pa.	6.5	100,000	52,030,950	70	1.00
Richmond, Va.	9	116,000	108,191,449	75	1.75
Rochester, N. Y.	20 3-5	210,000	154,035,6[illegible]5	82	1.97
Sacramento, Cal.	42-5	55,000	30,400,000	40	1.60
Saginaw, Mich.	16	62,000	25,210,038	65	[illegible].02
San Antonio, Tex.	36	125,000	70,000,000	75	1.45
San Diego, Cal.	72	50,000	35,021,325	35	1.48
San Francisco, Cal.	43	500,000	493,288,889	60	1.96
Savannah, Ga.	6[illegible]	80,000	47,542,827	66⅔	1.22
Schenectady, N. Y.	8	75,000	46,851,735	75	2.15
Scranton, Pa.	19	150,193	72,509,180	80	1.48
Seattle, Wash.	80	290,000	185,317,470	60	3.35
Sioux City, Iowa.	47	65,000	8,743,128	25	8.87
Somerville, Mass.	4[illegible]	77,000	63,658,953	100	1.86
Springfield, Ill.	7[illegible]	70,000	10,000,000	20	7.98
Salt Lake City, Utah.	47	100,000	52,194,220	50	3.82
Springfield, Mass.	38[illegible]	85,000	107,875,780	90	1.48
Springfield, O.	45	60,000	22,500,000	33⅓	3.45
St. Joseph, Mo.	9[illegible]	130,000	40,000,000	60	1.30
St. Louis, Mo.	61[illegible]	750,000	533,456,571	66	2.22
St. Paul, Minn.	55[illegible]	235,000	104,775,800	50	3.20
Syracuse, N. Y.	16	133,000	101,255,493	100	1.83
Tacoma, Wash.	35[illegible]	120,000	53,925,693	60	1.40
Taunton, Mass.	50	31,000	22,699,904	100	2.05
Toledo, O.	28	200,000	79,514,200	60	3.38
Topeka, Kan.	8 1-5	50,000	45,000,000	100	1.56
Trenton, N. J.	9	100,000	66,656,728	100	1.74
Troy, N. Y.	9[illegible]	76,000	55,981,974	100	1.80
Utica, N. Y.	9	75,000	42,712,914	66⅔	1.82
Washington, D. C.	69[illegible]	345,000	312,473,714	66⅔	1.50
Williamsport, Pa.	7.3	40,000	14,200,000	60	2.65
Wilmington, Del.	10.2	95,000	50,000,000	100	1.50
Worcester, Mass.	38[illegible]	144,470	13[illegible],384,202	100	1.64
Yonkers, N. Y.	21	80,000	67,019,705	70	2.42

STATE AND TERRITORIAL STATISTICS

STATES AND TERRITORIES.	Gross Area in Square Miles.	Extreme Breadth, Miles.	Extreme Length Miles.	CAPITALS
Alabama	52,250	200	330	Montgomery
Alaska Ter	590,884	800	1,100	Juneau
Arizona Ter	113,020	335	390	Phœnix
Arkansas	53,850	275	240	Little Rock
California	158,360	375	770	Sacramento
Colorado	103,925	390	270	Denver
Connecticut	4,990	90	75	Hartford
Delaware	2,050	35	110	Dover
Dist. of Col	70	9	10	Washington
Florida	58,680	400	460	Tallahassee
Georgia	59,475	250	315	Atlanta
Idaho	84,800	305	490	Boisé
Illinois	56,650	205	380	Springfield
Indiana	36,350	160	265	Indianapolis
Iowa	56,025	300	210	Des Moines
Kansas	82,080	400	200	Topeka
Kentucky	40,400	350	175	Frankfort
Louisiana	48,720	280	275	Baton Rouge
Maine	33,040	205	235	Augusta
Maryland	12,210	200	120	Annapolis
Massachusetts	8,315	190	110	Boston
Michigan	58,915	310	400	Lansing
Minnesota	83,365	350	400	St. Paul
Mississippi	46,810	180	340	Jackson
Missouri	69,415	300	280	Jefferson C'y
Montana	146,080	580	315	Helena
Nebraska	77,510	415	205	Lincoln
Nevada	110,700	315	485	Carson City
New Hamp	9,307	90	185	Concord
New Jersey	7,815	70	160	Trenton
N. Mexico Ter.	122,580	350	390	Santa Fé
New York	49,170	320	310	Albany
N. Carolina	52,250	520	200	Raleigh
N. Dakota	70,795	360	210	Bismark
Ohio	41,060	230	205	Columbus
Oklahoma	70,057	585	210	Guthrie
Oregon	96,030	375	290	Salem
Pennsylvania	45,215	300	180	Harrisburg
Rhode Island	1,250	35	50	Providence
S. Carolina	30,570	235	215	Columbia
South Dakota	77,650	380	245	Pierre
Tennessee	42,050	430	120	Nashville
Texas	265,780	760	620	Austin
Utah	84,970	275	345	Salt Lake C'y
Vermont	9,565	90	155	Montpelier
Virginia	42,450	425	205	Richmond
Washington	69,180	340	230	Olympia
W. Virginia	24,780	200	225	Charleston
Wisconsin	56,040	290	300	Madison
Wyoming	97,890	365	275	Cheyenne
Total U. S.	3,166,484	2,710	1,600	

REPRESENTATIVE HOTELS IN LEADING CITIES.

United States.

Albany, N. Y.: Hampton, New Kenmore, Stanwix, Ten Eyck.
Atlanta, Ga.: Aragon, Kimball House, Piedmont.
Atlantic City, N. J.: Arlington, Chalfonte, Marlborough-Blenheim, Shelburne.
Augusta, Ga.: Bon Air, Genesta.
Austin, Texas: Sutor, Tremont.
Baltimore, Md.: Belvedere, Caswell, Emerson, Rennert, Stafford.
Birmingham, Ala.: Hillman, New Florence.
Bisbee, Arizona: Copper Queen.
Boston, Mass.: Essex, Parker House, Touraine, Youngs.
Bridgeport, Conn.: Atlantic, Windsor.
Buffalo, N. Y.: Broezel, Iroquois, Lafayette, Statler.
Butte, Mont.: Finlen, Thornton.
Camden, N. J.: West Jersey House.
Canton, O.: Courtland, McKinley.
Charleston, S. C.: Argyle, Charleston, St. John.
Charleston, W. Va.: Kanawha, Ruffner.
Charlotte, N. C.: Sellwyn.
Chicago, Ill.: Auditorium Annex, Blackstone, Congress, Grand Pacific, Great Northern, La Salle, New Breevort, Sherman, Stratford.
Cincinnati, O.: Gibson House, Havlin, Sinton, St. Nicholas.
Cleveland, O.: Colonial, Euclid, Hollenden.
Columbus, O.: Chittenden, Hartman, Southern.
Dallas, Texas: Imperial, Oriental, Southland, St. George.
Denver, Colo.: Albany, Brown Palace, Savoy.
Des Moines, Iowa: Chamberlain, Savery.
Detroit, Mich.: Cadillac, Griswold House, Pontchartrain, Wayne.
Duluth, Minn.: Spalding, St. Louis.
El Paso, Tex.: Sheldon, St. Regis.
Erie, Pa.: Park View, Reed.
Evansville, Ind.: Acme, St. George.
Fall River, Mass.: Evans, Mellen.
Ft. Worth, Texas: Delaware, Touraine, Worth.
Galveston, Texas: Palmetto, Royal, Tremont.
Grand Rapids, Mich.: Morton, Pantlind.
Harrisburg, Pa.: Bolton, Commonwealth.
Hartford, Conn.: Allyn, Heublein, New Dom.
Helena, Mont.: Broadwater, Grandon, Helena.
Houston, Texas: Brazos, Macatee, Rice.
Indianapolis, Ind.: Claypool, Grand, New English, Denison, Edwards.
Jacksonville, Fla.: Windsor.

REPRESENTATIVE HOTELS IN LEADING CITIES.

Kansas City, Mo.: Baltimore, Coates, Kupper, Midland, Savoy.
Knoxville, Tenn.: Cumberland, Imperial.
Lawrence, Kan.: Lawrence, New Eldridge.
Lexington, Ky.: Leland, Phoenix.
Lincoln, Neb.: Lincoln, Lindell.
Little Rock, Ark.: Capitol, Marion.
Los Angeles, Cal.: Alexandria, Angelus, Haywood, Hollenbach, Van Nuys.
Louisville, Ky.: Galt, Old Inn, Seelbach.
Lowell, Mass.: Franklin, St. Charles.
Manchester, N. H.: New Manchester, Oxford.
Memphis, Tenn.: Cordova, Peabody.
Milwaukee, Wis.: Pfister, Plankington House, St. Charles.
Minneapolis, Minn.: Dykeman Hyser, Nicollet, Radisson, Rogers, West.
Mobile, Ala.: Battle House, Bienville, Cawthorn.

Nashville, Tenn.: Duncan, Maxwell.
New Bedford, Mass.: Manhattan, Parker.
New Haven, Conn.: Davenport, Moseley's, New Haven, The Garde.
New Orleans, La.: Commercial, Cosmopolitan, De Soto, Grunewald ,Monteleone, St. Charles.
New York, N. Y.: Astor House, Belmont, Breslin, Gotham, Hermitage, Hoffman House, Holland, Hotel Astor, Imperial, Knickerbocker, Manhattan, Martinique, Netherlands, Plaza, Prince George, Savoy, St. Regis, Victoria, Waldorf-Astoria.
Niagara Falls, N. Y.: Cataract, Imperial, International, Prospect House.
Norfolk, Va.: Loraine, Monticello.

Oakland, Cal.: Albany, Crellin.
Omaha, Neb.: Henshaw, Iler-Grand, Merchants, New Murray, Loyal, Rome.

Pasadena, Cal.: Green, Raymond.
Peoria, Ill.: Fay, National.
Philadelphia, Pa.: Bellevue-Stratford, Bingham, Colonnade, Continental, St. James, Walton.
Phoenix, Ariz.: Adams, Commercial.
Pittsburg, Pa.: Colonial and Annex, Duquesne, Fort Pitt, Henry, Lincoln, Schenley.
Portland, Me.: Lafayette, New Falmouth, West End.
Portland, Ore.: Oregon, Portland.
Prescott, Ariz.: Burke.
Providence, R. I.: Crown, Narragansett.

Reading, Pa.: Mansion, Penn.
Redlands, Cal.: Casa Loma.
Richmond, Va.: Jefferson, Richmond.
Riverside, Cal.: Glenwood.

REPRESENTATIVE HOTELS IN LEADING CITIES.

Rochester, N. Y.: Eagleston, Powers, Rochester, Seneca, Whitcomb.

St, Joseph, Mo.: Metropole, St. Charles.

St. Louis, Mo.: Buckingham, Jefferson, Marquette, Maryland, New Planters, Southern, Washington.

St. Paul, Minn.: Frederick, Magee, Ryan, St. Paul.

Salt Lake City, Utah: Cullen, Kenyon, Knutsford, Newhouse, Semloh, Utah, Wilson.

San Antonio, Texas: Bexar, Hot Wells, Menger.

San Diego, Cal.: Hotel del Coronado.

San Francisco, Cal.: Argonaut, Fairmont, Palace, St. Francis.

Santa Barbara, Cal.: Arlington, Potters.

Savannah, Ga.: De Soto.

Schenectady, N. Y.: Edison, Vendome.

Scranton, Pa.: Casey, Jermyn, Schadt.

Seattle, Wash.: Butler, Perry, Savoy, Sorrento, Washington.

Spokane, Wash.: Spokane, Pennington, Victoria.

Springfield, Mass.: Cooley's, Massasoit, Worthy.

Springfield, O.: Arcade, Bookwalter.

Syracuse, N. Y.: Onandaga, St. Cloud, Vanderbilt, Yates.

Tacoma, Wash.: Donnelly, Tacoma.

Toledo, O.: Secor, Boody, St. Charles.

Trenton, N. J.: Trenton, Windsor.

Troy, N. Y.: Mansion House, Rensselaer.

Tucson, Ariz.: Santa Rita.

Utica, N. Y.: Braggs, Butterfield.

Washington, D. C.: Arlington, New Willard, Raleigh, Shoreham, St. James.

Wilkesbarre, Pa.: Reddington, Sterling, Terminal.

Wilmington, Del.: Clayton House, Wilmington.

Worcester, Mass.: Bay State, Warren.

Youngstown, O.: Tod House.

Canada.

Calgary, Alta.: Alberta.

Edmonton, Alta.: Alberta.

Fort William, Ont.: Avenue.

Halifax, N. S.: Halifax.

Hamilton, Ont.: Royal, Waldorf.

Lethbridge, Alta.: Lethbridge.

London, Ont.: Tecumseh.

Montreal, Que.: La Corona, Place Viger, The Queens, "St. Lawrence Hall," The Welland, Windsor.

Ottawa, Ont.: Russell House.

Prince Albert, Sask.: Windsor, Avenue.

REPRESENTATIVE HOTELS IN LEADING CITIES.

Quebec, Que.: Chateau Frontenac.
Regina, Sask.: King's.
St. Johns, N. B.: Royal.
Sault Ste. Marie, Ont.: International.
Saskatoon, Sask.: Flannigan.
Toronto, Ont.: Iroquois, King Edward, Queens, Rossin House.
Vancouver, B. C.: Astor, Commercial, Metropole, St. Francis, Strand, Vancouver.
Victoria, B. C.: Driard, Empress.
Winnipeg, Man.: Clarendon, Marriaggi, Royal Alexandre.

Mexico.

Aguascalientes: Belina.
Celaya: Gomez.
Chapala: Arzapalo, Rivera.
Chihuahua: Palacio, Robinson.
Colima: Central.
Cordoba: Cevallos.
Cuautla: San Diego.
Cuernavaca: Morelos, Bella Vista.
Culiacan: Rosales.
Guadalajara: Cosmopolita, Garcia.
Guanajuato: Wood's Hotel.
Guaymas: Albin.
Irapuato: Jardin.
Jalapa: Gran.
Leon: Gto. Guerra.
Matehuala: Villazon.
Mazatlan: Central.
Merida: Imperial.
Mexico City: Geneve, Iturbide, Jardin, Palace, New Porter's, Sanz, St. Francis.
Monterey: Iturbide.
Morelia: Oseguera.
Oaxaca: Chavez, Hotel Francia.
Ocotlan: Rivera.
Orizaba, V. C.: Hotel de Francia.
Pachuca: Grenfall Hotel, Hotel de los Banos.
Parral: Fuentes.
Popo Park: ' Popo Park.
Puebla: Hotel del Pasaje.
Queretaro: Gran.
Saltillo: Coahuila.
San Luis Potosi: Sanz.
Silao: San Julian.
Tampico: Continental.
Tepic: La Bola del Oro.
Toluca: Andueza.
Torreon: Hotel Salvador.
Veracruz: Diligencias.
Zacatecas: La Plaza.

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YEARLY CALENDAR, 1912

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Arms Pocket Book & Leather Novelty Co.
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